Appendix G

Geology and Soils

Appendix G – Geology and Soils

Table G-1 identifies the potential hazards associated with each soil unit found in the study area. The segments are separated into the respective soil units they cross. The USDA classifies each soil unit in a regional context, and the characteristics of the soil within each specific location will vary. Hazards depend on the slope, depth of the soil, water exposure, and type and extent of disturbance. The locations of potential hazards identified by the USDA and based on the soil unit present are mapped in Exhibits G-1 through G-32. Potential hazards analyzed include erosion, expansive clays, and soils containing gypsum. In addition to the methods and benchmarks described below, engineering judgment was also used to identify these areas.

Table G-1
Potential Soil Hazards

		Potential Soil Hazards				
Segment	**Soil Unit, percent slope**	**Water Erosion**	**Wind Erosion**	**Expansive Clays**	**Shallow Bedrock**	**Gypsum**
Segment 1	Av – Avalon sandy loam, 2-5%	X	X			
	BA – Badland		X	X	X	X
	BB – Badland-Monierco-Rock outcrop complex			X	X	
	BT – Blancot- Notal association, gently sloping	X		X		
	DS – Doad-Sheppard-Shiprock association, rolling					
	Ha – Haplargids-Blackston-Torriorthents complex, very steep				X	
	RO – Rock outcrop				X	
	Tr – Turley clay loam, 1-3%					
	Tt – Turley clay loam, wet, 0-2%		X			
Segment 2	BA – Badland		X	X	X	X
	BC – Badland-Rock outcrop-Persayo complex, extremely steep				X	
	BT – Blancot- Notal association, gently sloping	X		X		
	FA – Farb-Persayo-Rock outcrop complex, very steep		X		X	
	Ha – Haplargids-Blackston-Torriorthents complex, very steep				X	
	SV – Stumble sandy clay loam, gently sloping					
	SW – Stumble-Fruitland association, gently sloping		X			
	Wr – Werlog loam					

Table G-1
Potential Soil Hazards

Segment	Soil Unit, percent slope	Potential Soil Hazards				
		Water Erosion	Wind Erosion	Expansive Clays	Shallow Bedrock	Gypsum
Segment 3	BT – Blancot- Notal association, gently sloping	X		X		
	FA – Farb-Persayo-Rock outcrop complex, very steep		X		X	
	GY – Gypsiorthids-Badland-Stumble complex, moderately steep		X		X	X
	Ha – Haplargids-Blackston-Torriorthents complex, very steep				X	
	SW – Stumble-Fruitland association, gently sloping		X			
Segment 4	AT – Atrac-Florita-Travessilla association, hilly	X	X		X	
	BT – Blancot- Notal association, gently sloping	X		X		
	BU – Buckle silt loam, gently sloping	X				
	FA – Farb-Persayo-Rock outcrop complex, very steep		X			
	GY – Gypsiorthids-Badland-Stumble complex, moderately steep		X		X	X
	Ha – Haplargids-Blackston-Torriorthents complex, very steep				X	
Segment 5	AT – Atrac-Florita-Travessilla association, hilly	X	X		X	
	Ax – Avalon sandy loam, 5-8%	X	X			
	BT – Blancot- Notal association, gently sloping	X		X		
	BU – Buckle silt loam, gently sloping	X				
	Db – Doak loam, 1-3%					
	Ha – Haplargids-Blackston-Torriorthents complex, very steep				X	
	RT – Rock outcrop-Travessilla-Weska complex, extremely steep				X	
	TA – Travessilla-Weska-Rock outcrop complex, moderately steep		X		X	
	TW – Twick-Silver Association, moderately sloping			X	X	

Table G-1
Potential Soil Hazards

Segment	Soil Unit, percent slope	Potential Soil Hazards				
		Water Erosion	Wind Erosion	Expansive Clays	Shallow Bedrock	Gypsum
Segment 6	5 – Arboles Clay, 3-10%		X	X		
	24 – Dulce-Travessilla-Rock outcrop complex, 6-50%		X		X	
	44 – Mikim loam, 3-12%					
	50 – Pescar fine sandy loam		X			
	56 – Pulpit loam				X	
	58 – Rock outcrop				X	
	76 – Witt loam, 3-8%	X				
	82 – Zyme-Rock outcrop complex, 12-25%				X	
Segment 7	5 – Arboles Clay, 3-10%		X	X		
	10 – Bayfield silty clay loam, 1-3%					
	16 – Buckle loam		X			
	25 – Durango cobbly loam, 3-20%					
	62 – Sili clay loam, 1-3%		X			
	63 – Sili clay loam, 3-6%		X			
	70 – Ustic Torriorthents-Ustollic Haplargids, 12-60%	X				
	76 – Witt loam, 3-8%	X				
Segment 8	5 – Arboles Clay, 3-10%		X	X		
	8 – Baca Variant loam, 3-12%					
	10 – Bayfield silty clay loam, 1-3%					
	14 – Bodot clay, 3-10%		X		X	
	25 – Durango cobbly loam, 3-20%					
	63 – Sili clay loam, 3-6%		X			
	70 – Ustic Torriorthents-Ustollic Haplargids, 12-60%	X				
	82 – Zyme-Rock outcrop complex, 12-25%				X	

Segment 1 – Shiprock Substation Segment

Segment 1 primarily overlies the Blancot-Notal and Badland-Monierco-Rock outcrop complexes. The soils correspond to the topographic setting with the shallow Badland-Monierco-Rock outcrop complex found on the high elevation ridges and deep soils characterizing the Blancot-Notal on the flat, low lying valleys in between. The Badland-Monierco-Rock outcrop complex is approximately 40 percent Badland, 30 percent Monierco fine sandy loam, and 20 percent Rock outcrop, and all tend to be intermingled throughout the area. Badlands consist of barren shale intersected by drainage ways on a 5 to 30 percent slope and may exhibit slope failures or contain expansive clays. Rock outcrops are present as exposed Pictured Cliffs Sandstone at the tops of ridges and benches. The Monierco complex is the only soil present, but it is shallow ranging from 12 to 14 inches thick. It is derived predominantly from the underlying Kirtland Shale and Fruitland Formation and is composed of a surface layer of fine sandy loam overlying brown clay loam and sandy clay loam.

The Blancot-Notal association was formed from sediments eroding from the surrounding ridges and mesas and alluvium derived from the Pictured Cliffs Sandstone and Kirtland Shale and Fruitland Formations. The association is found in the low lying valleys with deep soils over 5 feet. The association is composed of approximately 55 percent Blancot loam and 25 percent Notal silty clay loam. Both are found on fans, but the Blancot loam is more commonly found in upland valleys while the Notal silty clay loam is on valley bottoms. The clay content of the Blancot loam increases with depth, with a surface layer of pale brown loam, light brownish gray clay loam to a depth of 13 inches, and light grayish brown and grayish brown sandy clay loam and clay loam to the depth of the survey. The Notal silty clay loam can contain fat clays that may have a moderate shrink-swell potential. It has a surface layer of brown silty clay loam with a grayish brown clay subsoil. From field surveillances, a crust was observed on the soil from drying action by the sun. In combination with the low elevation and moderate to slow permeability, the Blancot-Notal association may hold standing water. In addition, large sandstone boulders were found on the surface in the vicinity of the San Juan Power Plant. Water erosion can be severe.

A Badlands complex and Avalon sandy loam unit can also be found in small pockets in Segment 1. Badlands have the same characteristics as described above, but is the only soil in the unit as opposed to the 40 percent it composes in the Badland-Monierco-Rock outcrop complex. Avalon sandy loam is a deep soil found on mesas and plateaus. It can contain particles ranging from clays to gravels and was derived from the underlying sandstone and shale. It has a surface layer of brown sandy loam, a subsoil of brown loam up to 14 inches thick, white loam 30 inches below, and light yellowish brown sandy clay loam to the depth of the survey. Water capacity is high, and both wind and water erosion are potential hazards.

Segment 2 – Pinon Mesa Segment

The eastern half of Segment 2 has soils and topography similar to Segment 1 but tends to have more drastic canyons and ridges at higher elevations that will make it more difficult to maneuver construction equipment. It is has a higher percentage of Badlands and rock outcrops than does Segment 1 but also has areas of the Blancot-Notal association in the valleys with deep arroyos. The three main associations in the eastern half include Badlands, Badland-Rock outcrop-Persayo complex, and the Blancot-Notal. The Badlands and rock outcrops are similar to Segment 1 with shale from the Fruitland Formation and Kirtland Shale at the surface. As the study area progresses east, the outcropping rock changes to sandstone and shale from the Nacimiento and Animas Formations.

In addition to soils from the Blancot-Notal association, soils are also present from the Badland-Rock outcrop-Persayo complex. Persayo clay loams make up approximately 20 percent of the complex and can be found on 30 to 40 percent slopes. The soil is predominantly derived from shale and is shallow with bedrock found at a depth of 16 inches. The surface layer is a light brownish gray clay loam with some gravel and similar subsoil with a higher silt content.

The western half of Segment 2 tends to feature steep slopes and deeper soils near the La Plata River. The associations are found in smaller pockets than they are in the eastern half and are composed of the Farb-Persayo-Rock outcrop complex, Haplargids-Blackston-Torriorthents complex, and Werlog loam. The Farb-Persayo-Rock outcrop complex is approximately 40 percent Farb fine sandy loam, 30 percent Persayo clay loam, and 20 percent Rock outcrop. The Rock outcrops are barren sandstone on ridges and breaks. The Persayo soils are the same as described above, while the Farb fine sandy loam is derived from sandstone rather than shale. It is shallow with bedrock at a depth of 10 inches. The surface layer is a pale brown fine sandy loam about 7 inches thick, and it has a thin underlying layer of brown sandy clay loam. Wind erosion is a threat to the Farb unit.

The Haplargids-Blackston-Torriorthents association can be found along Route 170, more commonly along the northern edge of the study area in Segment 2. It is found on steep slopes (ranging from 8 to 50 percent), on mesas, terraces and terraces. The units are intermingled with 45 percent Haplargids, 30 percent Blackston gravelly loam, and 20 percent Torriorthents. Haplargids and Blackston tend to be deeper while bedrock is found at 15 inches in Torriorthents. Small areas of rock outcrops can be found in ledges, shelves and breaks. The characteristics of the Haplargids unit tend to vary widely throughout the area but the unit typically has a surface layer of dark brown cobbly sandy loam, subsoil of brown and yellowish brown sandy clay loam, and a substratum at 26 inches of light brownish gray, light gray and pale olive cobbly sandy clay loam and loam. The Blackston soil is derived from mixed alluvium and has a high gravel content. Gravelly clay loam is found in the upper 9 inches while the substratum is a gravelly sand. Cobbles can also be found in the Torriorthents unit although the soil layer is only 15 inches. The surface layer is predominantly cobbles while the lower 12 inches have a higher clay and sand content.

Werlog loam is present in a relatively small portion of Segment 2 in the flood plain surrounding the La Plata River. The land is flat and the loam is a derivation of the river alluvium. Finer particles are found at the surface with a 60-inch layer of grayish brown loam and light brownish gray and brown clay loam. The base is composed of sand, gravel and cobbles which could provide challenges during construction or site investigation.

Segment 3 – South Glade Segment

The eastern trending portion of Segment 3 is quite different from the previous segments. The topography is flat, gently rolling land with shallow arroyos. It is overlain with shallow to deep sands and is known as the Glades. From the La Plata River to approximately 1.5 miles after the proposed transmission line makes a turn to the northeast, the line crosses the Farb-Persayo-Rock outcrop complex and the Stumble-Fruitland association. Rock outcrops will be the Nacimiento Formation except for a minor portion of Ojo Alamo sandstone near the La Plata River. The Farb-Persayo-Rock outcrop is similar to that mentioned above except the Farb unit appears to dominate given the underlying sandstone.

The Stumble-Fruitland association is found on flat lands, typically fans and valley sides. The units are similar and the association is generally a deep, loose sandy soil with high permeability. The association in the segment typically includes approximately 40 percent Stumble loamy sand and 30 percent Fruitland sandy loam. The Stumble unit has a surface layer of brown loamy sand overlying light yellowish brown and pale brown loamy sand and sand with gravel content at the base of the survey depth. The Fruitland unit is characterized with brown sandy loam at ground surface and pale brown and light yellowish brown sandy loam at the base. The elevation and flat slope of the land prevents most runoff and water erosion. Wind erosion is a severe hazard given the lack of cohesion and dense scrubland.

The remainder of the proposed transmission line in the segment trending in the northeastern direction primarily crosses the finer grained Blancot-Notal formation described above. However, since the soil overlies a sandstone rather than a shale, it is likely to have a higher content of coarse grained material. In this segment, the proposed access roads span out a maximum of 3 miles from the transmission line footprint. The roads will cross the Blancot-Notal association, Farb-Persayo-Rock outcrop complex, and the Gypsiorthids-Badland-Stumble complex.

The Gypsiorthids-Badland-Stumble complex is found on a wide range of landforms from hills and knolls to valleys with slopes from 5 to 30 percent. The complex is made up of 35 percent Gypsiorthids, 35 percent Badlands, and 15 percent Stumble loamy sand, although all units tend to be intermingled. Badlands are barren shale uplands with intersecting arroyos and gullies. The Stumble unit is similar to that described above. Gypsiorthids can be shallow or deep and is derived from gypsum. Gypsum is detrimental to concrete structures as it can erode the material. The unit doesn’t have consistent profile, but it typically has a surface layer of pale yellow sandy loam and gypsum bedrock at a depth of 16 inches.

Segment 4 – North Glade Segment

Segment 4 has topography similar to Segment 3, although there may be steeper hills and canyons as the SJBEC Project approaches the state line. The southwest portion of Segment 4 has the same soils as the northeast portion of Segment 3. Segment 4 overlies the Blancot-Notal complex and may cross pockets of the Haplargids-Blackston-Torriorthents association and Farb-Persayo-Rock outcrop complex. When the line takes a turn in the northerly direction, the outcropping rock changes from the Nacimiento Formation to the San Jose formation, which in this location is mainly sandstone. The soils also change to the Atrac-Florita-Travessilla association on hills and higher elevations and Buckle silt loam in the flatter valleys.

The Atrac-Florita-Travessilla association is found on hills, fans, mesas and breaks and is derived from sandstones and shales. The Atrac and Florita units tend to be deep soils and make up 35 percent and 30 percent of the association, respectively. The Travessilla unit is typically only about 12 inches of brown very fine sandy loam with underlying sandstone and is 20 percent of the association. Atrac loam has a surface layer of brown loam, a subsoil of light brown and yellowish brown sandy clay loam. Soil below 21 inches is pale brown sandy clay loam and sandy loam. The Florita unit has a higher sand content with a surface layer of dark grayish brown sandy loam over light yellowish brown loamy coarse sand. Both wind and water erosion can be a problem for the association.

Buckle silt loam is found on fans and valley bottoms with flat slopes. It has a high fines content and is very deep. The surface layer is a brown silt loam and the soil below ranges from pale brown to light brownish gray silty clay loam. Water erosion is a severe concern.

Segment 5 – State Line Segment

The first three miles of the segment traverse terrain similar to the northern portion of Segment 4, overlying the intermingled Atrac-Florita-Travessilla association and Buckle silt loam. The remainder of the segment overlies alternating outcropping bedrock from the San Jose Formation and Nacimiento Formation. The topography gets much steeper and rugged as the transmission line trends eastward and crosses into Colorado. The San Jose forms steep cliffs and sandstone surfaces in many places. Access to the transmission line could pose a problem to construction equipment when installing the towers.

The predominant soil through the segment is the Rock outcrop-Travessilla-Weska complex. The unit is found on extremely steep slopes on hills, breaks and mesas ranging from 30 to 70 percent. It is approximately composed of 40 percent rock outcrop, 30 percent Travessilla sandy loam, and 20 percent Weska silty clay loam, all of which are intermingled. Rock outcrops will be exposed San Jose Sandstone, much of which forms steep cliffs. The Travessilla is similar to that mentioned above except that it is shallower, and the sandstone bedrock outcrops at 9 inches. The

Weska is shallow as well; however, it overlies shale which dictates the composition. The surface layer is a grayish brown silty clay loam with grayish brown clay loam below. High runoff volumes will be of concern on the Weska and Rock outcrops because of the low permeability.

In between the large areas of Rock outcrop-Travessilla-Weska complex the access roads and transmission lines also cross portions of the Buckle silt loam, Travessilla-Weska-Rock outcrop complex, and Blancot-Fruitland association. All of these soils are units found in other parts of the line. The Travessilla-Weska-Rock outcrop complex is the same as the Rock outcrop-Travessilla complex, but it has different proportions: 40 percent Travessilla sandy loam, 30 percent Weska clay loam, and 25 percent Rock outcrop.

Approximately one mile before the line crosses the state border, it overlies the Twick-Silver association. The association is found on hills with slopes from 0 to 25 percent. It is composed of 55 percent Twick cobbly silty clay loam and 35 percent Silver cobbly silty clay loam. The Twick unit is a shallow soil that forms from shale. Brown cobbly silty clay loam is found on the surface, and the particles become finer with depth until the shale bedrock at a depth of 17 inches. The Silver soil is also derived from shale but it is a much deeper soil, extending to the depth of the survey. The surface layer and subsoil are reddish gray cobbly silty clay loam followed by a finer reddish gray clay at 24 inches. The clay content of both of these units has a shrink-swell potential which could pose a hazard to the access roads and tower structures. The clay also causes permeability to be low which causes moderate runoff.

Segment 6 – West Mesa Mountains

Segment 6 begins the Colorado portion of the transmission line and was mapped by a different soil survey. Therefore the unit names may not match up, although the soils may be similar. Additionally, it is mapped in much greater detail and for the purpose of this report it is unnecessary to describe each pocket of soil. The major units and any units that could pose a hazard are summarized below.

Topography of the beginning of the Colorado segment includes steep cliffs and outcrops, most notably those bordering the Animas River crossing. As the transmission line proceeds into Southern Ute land and the Mesa Mountains towards the north, there are rolling mesas and hills with high elevations. The vegetation is denser which also helps to maintain soil integrity. Segment 6 predominantly overlies the San Jose Formation with portions of the Nacimiento Formation outcropping in the Animus River area. The two major soil units include the Dulce-Travessilla-Rock outcrop complex and the Zyme-Rock outcrop complex.

The Zyme-Rock outcrop complex can be found in the first 3 miles of the Colorado portion of the line and in the middle of the northern trending stretch of the transmission line. It is found at higher elevations on hills and ridges and is composed of 50 percent Zyme clay loam and

30 percent Rock outcrop. The rock outcrop is exposed shale which has the potential for slope failure. The Zyme clay is shallow and derived from the underlying shale. The soil is a grayish brown clay loam and bedrock can be at depths ranging from 6 to 20 inches and exhibits varying degrees of weathering.

The Dulce-Travessilla-Rock outcrop complex is found on foothills and ridges with slopes ranging from 6 to 50 percent. It is approximately 40 percent Dulce sandy loam, 25 percent Travessilla sandy loam, and 25 percent Rock outcrop. The Rock outcrop will be areas of exposed sandstone. The Travessilla sandy loam appears to be the same as that mapped in New Mexico. It is a shallow soil consisting of light brownish gray to light yellowish brown sandy loam with sandstone bedrock at 11 inches. The Dulce soils are similar and are shallow with sandstone bedrock at depths from 8 to 20 inches. The surface layer is grayish brown sandy loam overlying pale brown sandy loam or soft weathered sandstone.

Segment 7 – East Mesa Mountains Segment

The majority of this segment crosses the Mesa Mountains and then traverses alluvial planes as it connects with the Iron Horse Segment. As the transmission line crosses to the lower elevation the slope is rolling but steep enough to prohibit large equipment. Access roads within the mountains are winding along small hills at high elevations. Outcropping rocks include the San Jose Formation with pockets of Quaternary alluvium that was deposited in the upland valleys. The major soil units include the Dulce-Travessilla-Rock outcrop complex mentioned above, Durango cobbly loam, and Buckle loam.

Buckle loam is found in the upland valleys within the mountains and is derived from sandstone. It is a deep soil and appears to be the same unit mapped in New Mexico. The surface layer is a light brownish gray loam overlying a brown clay loam subsoil. Water erosion can pose a problem depending on the clay content.

The Durango cobbly loam is found on mesa tops and ridge tops. It formed from a glacial outwash which left a large range of particle sizes. The surface layer is brown cobbly loam with light reddish brown to brown clay loam in the subsoil and light gray clay at the depth of the survey. It is recorded to have low soil strength and which will require extra design measures.

Segment 8 – Iron Horse Line Segment

The SJBEC Project will parallel an existing line along Segment 8 and connect with an expansion at the Iron Horse Substation. The topography of this segment looks significantly different from the rest of the transmission line. The land is relatively flat with pasture lands and small shrub cover. Soils in the area were formed from outwash from the Mesa Mountains and tend to be deep. The underlying rock is from the Animas formation, a volcanic deposit. There are many small pockets of different soils along the Segment but the primary units include the Zyme-Rock outcrop complex, Bodot clay, and Arboles clay.

Bodot clay is typically found on hills with 3 to 10 percent slopes. The unit includes about 30 inches of gray clay with underlying weathered shale. The permeability of the clay is low, and water erosion is a severe hazard. Erosion and slope stability will be driven by the degree of the slope, and given the flat topography, the Bodot clay may not be as problematic as it might be in other locations. New structures or access roads will not be built on this segment which will also minimize the risk. This unit is present in the area of the Iron Horse Substation and further site investigation will help to better assess the erosion hazard and consequential impact on the expansion of the substation.

Arboles clay is also found in many areas of the segment. It is typically found on side slopes and upland valleys. It is derived from shale alluvium and is a deep soil. The surface layer is a brown clay with a subsoil and substratum of brown and reddish yellow clay. The USDA has identified this clay to have a high shrink-swell potential which could impact any structures are built in on this soil unit. The soil has a high water capacity and if it is too dry, deep, wide cracks can form. This could have a significant impact on any roads in the area.

Another soil in the Iron Horse Substation vicinity is the Bayfield silty clay loam. It is found in flat, broad valleys and was derived from shale alluvium. It has a surface layer of grayish brown silty clay loam with a subsoil of pale brown silty clay. The substratum extends to the depth of the survey and includes light brownish gray and grayish brown silty clay loam and silty clay.

Soil Hazards

Erosion Potential

Soil deposition occurs over a long time period, and if the soil cover is removed from an area it could affect the surrounding vegetation and water resources. Wind and water erosion are two possible concerns. Table G-1 identifies soil units that are particularly sensitive to erosion.

The USDA uses a K factor to measure the susceptibility of a soil to sheet and rill erosion by water. This analysis uses Kw factors which indicate the credibility of the whole soil as opposed to Kf which only rates the erodibility of the fine-earth fraction. K values range from .02 to .69, and if the range is divided into low, moderate, and high potential, soils with a Kf value greater than or equal to 0.43 will have a high potential of water erodibility.

In order to estimate wind erosion, the USDA uses a wind erodibility index which assigns soils to eight groups. Soils in group 1 are most susceptible to wind erosion and those in group 8 are the least susceptible. Group classification is based on texture of the surface layer, size and durability of surface clods, rock fragments, organic matter, and a calcareous reaction. For this study, groups 1 through 4 are considered to have a high potential of wind erosion averaging at a minimum, 86 tons of soil per acre per year lost to wind.

Expansive Soils

Many soils with high amounts of clay can change volume when exposed to a change in water content. Two sets of criteria have been used to identify soil units that have a high shrink-swell potential. The definition provided by the USDA NRCS includes soils with a 6 percent or greater linear extensibility, i.e. the difference between the moist and dry length of a soil sample. The engineering community more commonly estimates the shrink-swell potential from the liquid limit and plasticity index. For this analysis a liquid limit greater than 40 and plasticity index greater than 25 was used as a benchmark. Soils below this limit may still be expansive but given that the analysis is based on limited data, only severe hazards were identified. If the shrink-swell potential of a soil is rated moderate to very high, shrinking and swelling can damage buildings, roads, and other structures. Thickness of the clay layer will also have a significant impact on the degree of volume change.

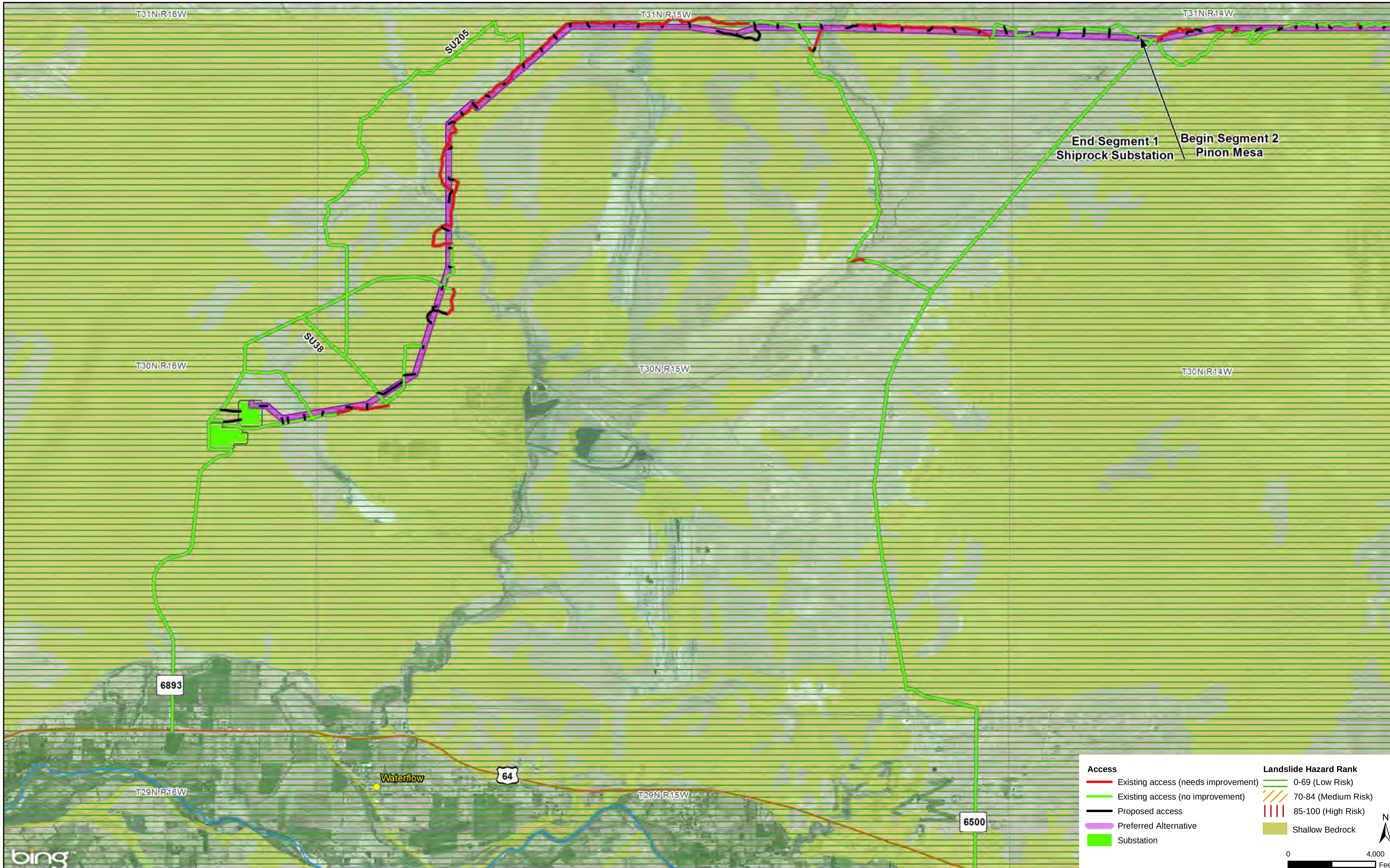
Gypsum

When present, gypsum can form minerals that degrade concrete, referred to as an alkali-silicate reaction. The USDA Soil Survey Handbook[1] identifies soils with more than one percent gypsum as having the potential to corrode concrete. Soils with more than 10 percent gypsum may cause hydrocollapse.

Reference

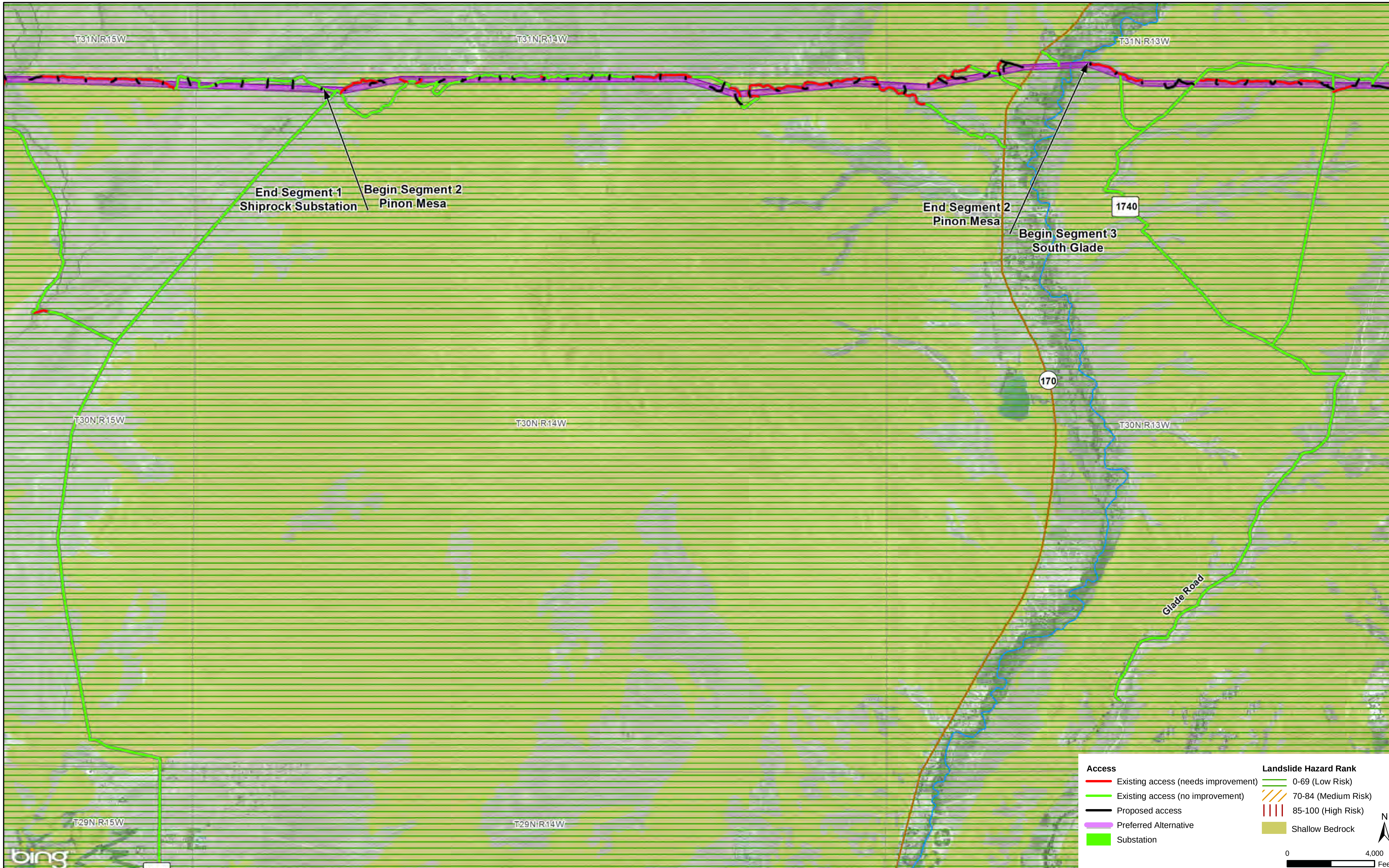
U. S. Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. Available online at: http://soils.usda.gov/technical/handbook/. Accessed October 2012.

[1] U.S. Department of Agriculture, NRCS 2012



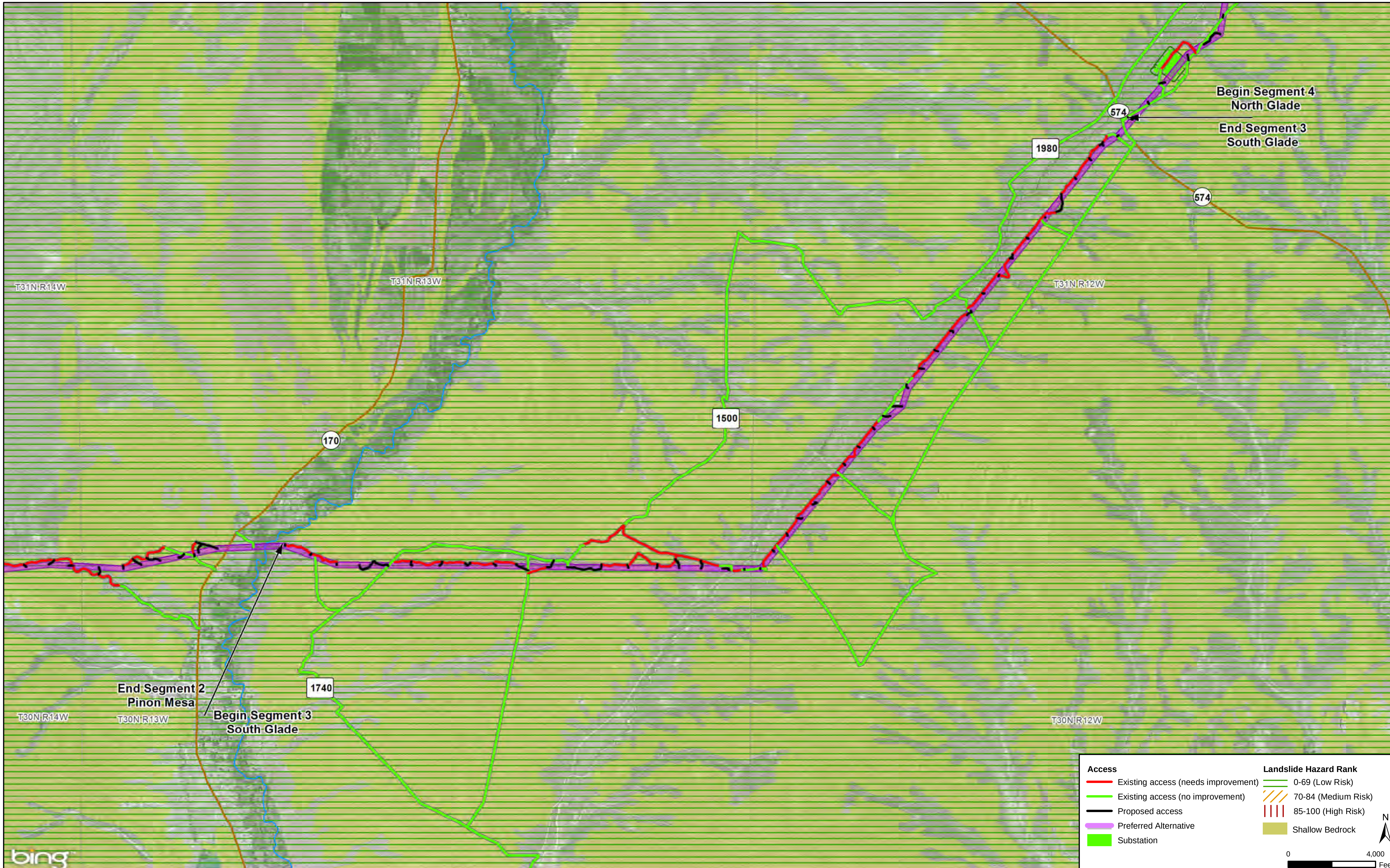
Source: FEMA 1996, USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-1 Preferred Alternative Segment 1 -- Geologic Hazards



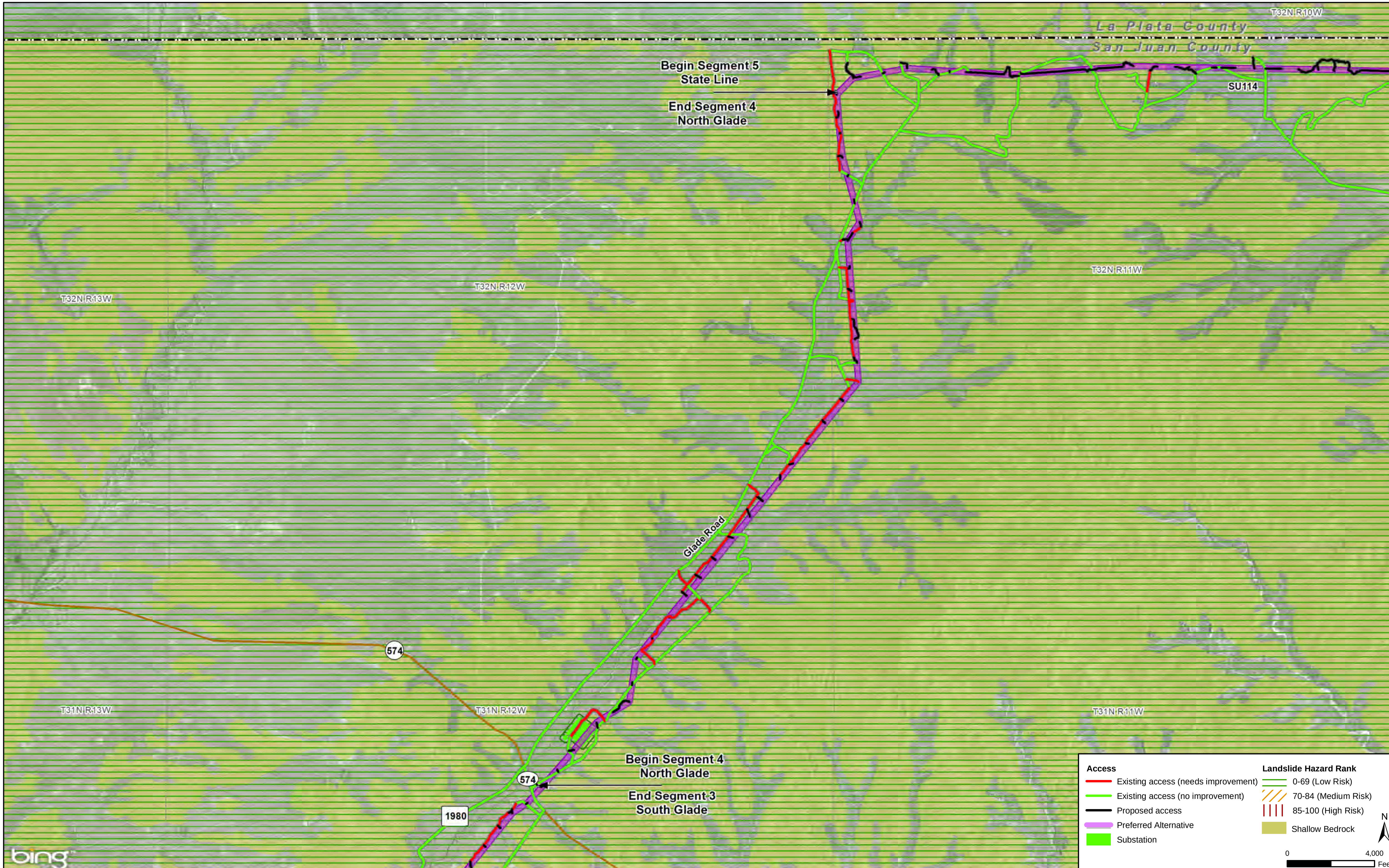
Source: FEMA 1996, USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-2 Preferred Alternative Segment 2 -- Geologic Hazards



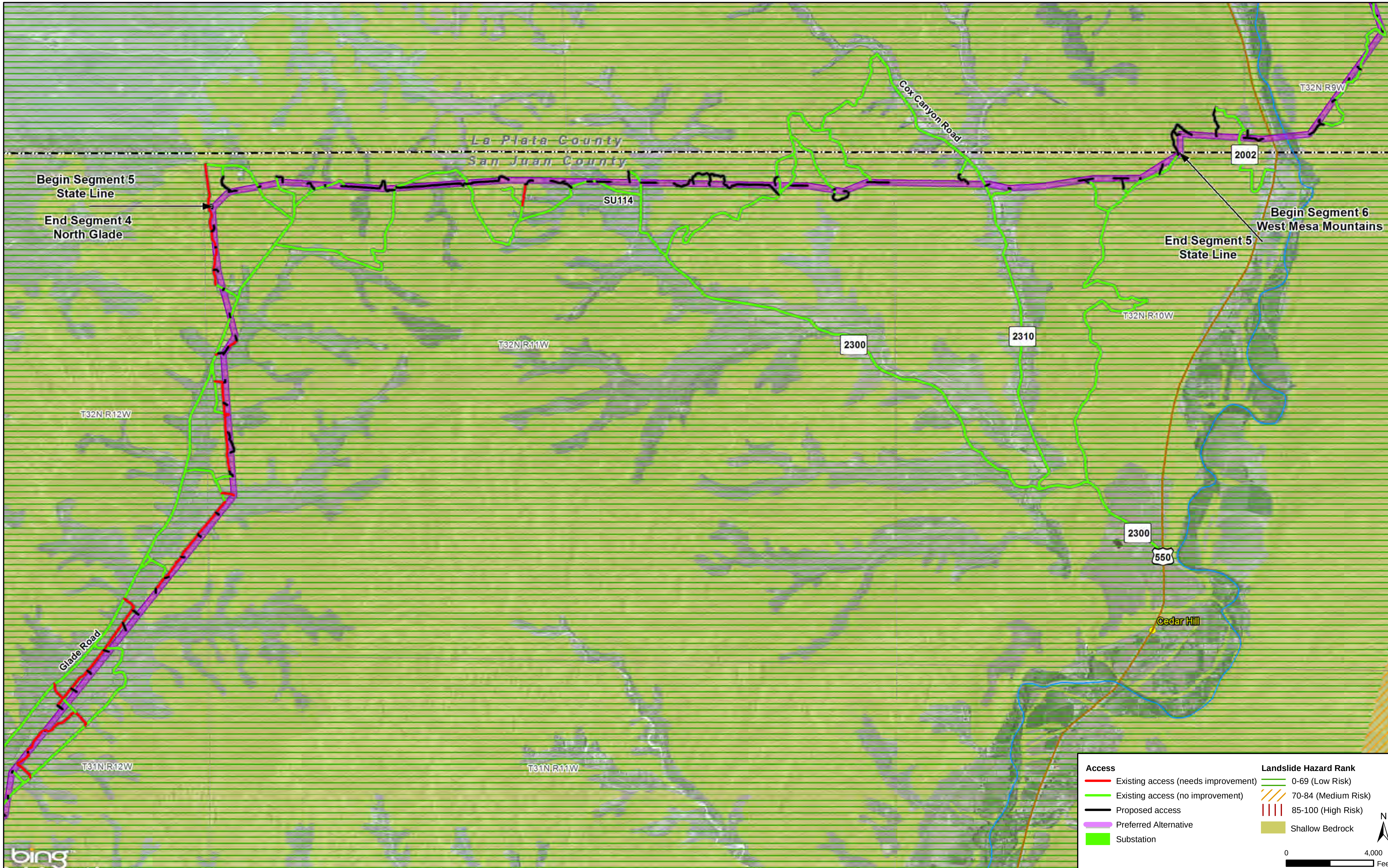
Source: FEMA 1996, USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-3 Preferred Alternative Segment 3 -- Geologic Hazards



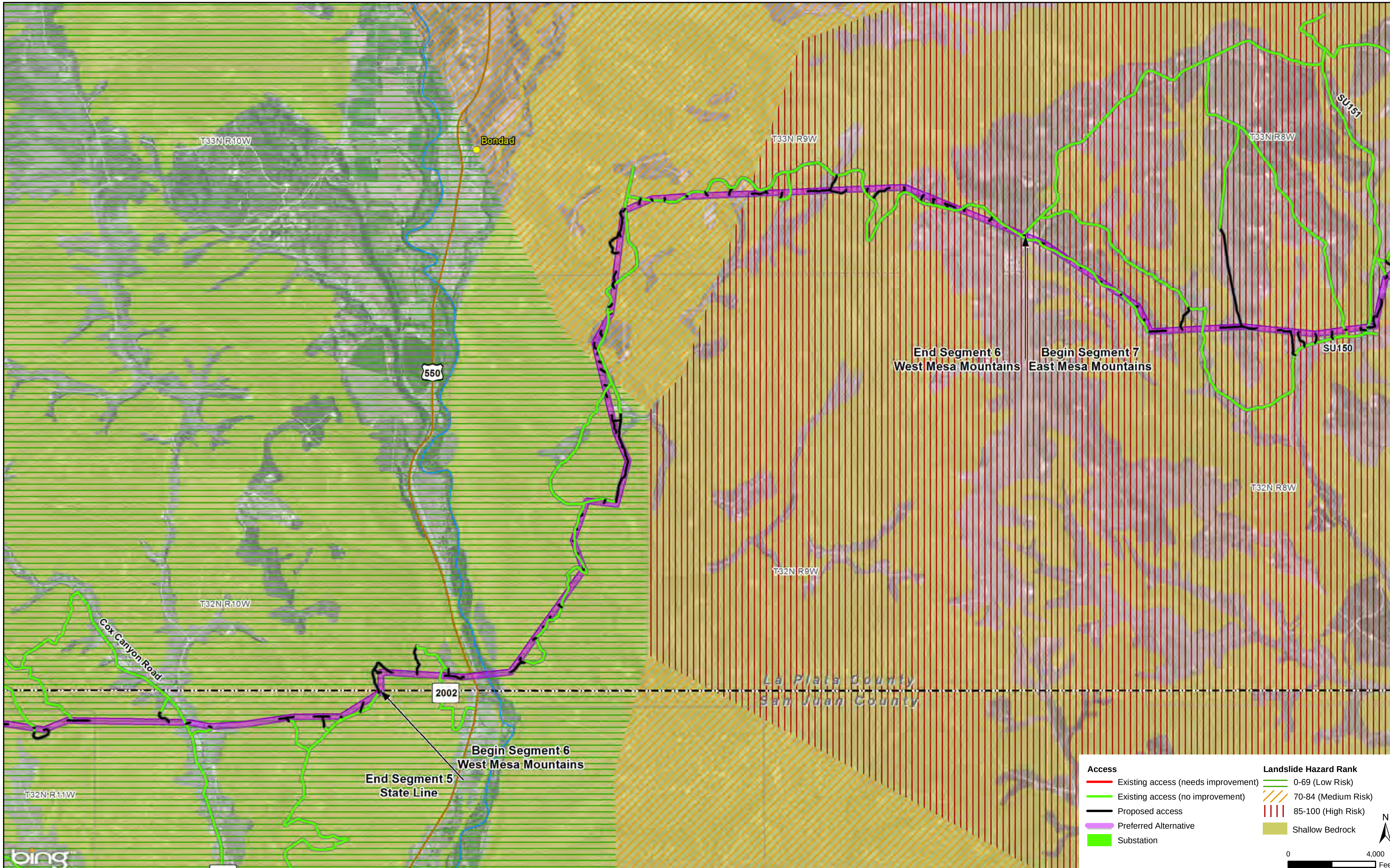
Source: FEMA 1996, USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-4 Preferred Alternative Segment 4 -- Geologic Hazards



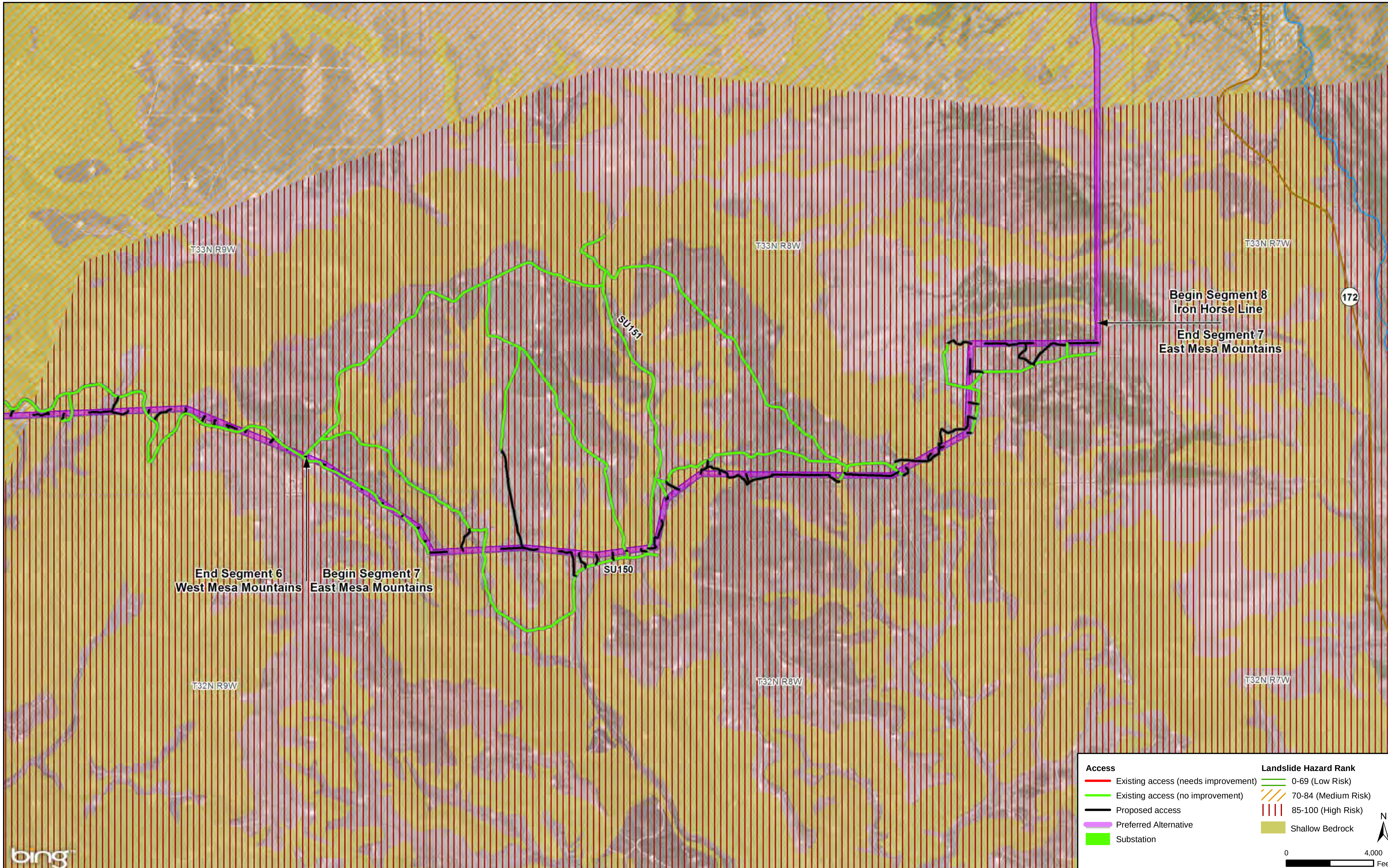
Source: FEMA 1996, USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-5 Preferred Alternative Segment 5 -- Geologic Hazards



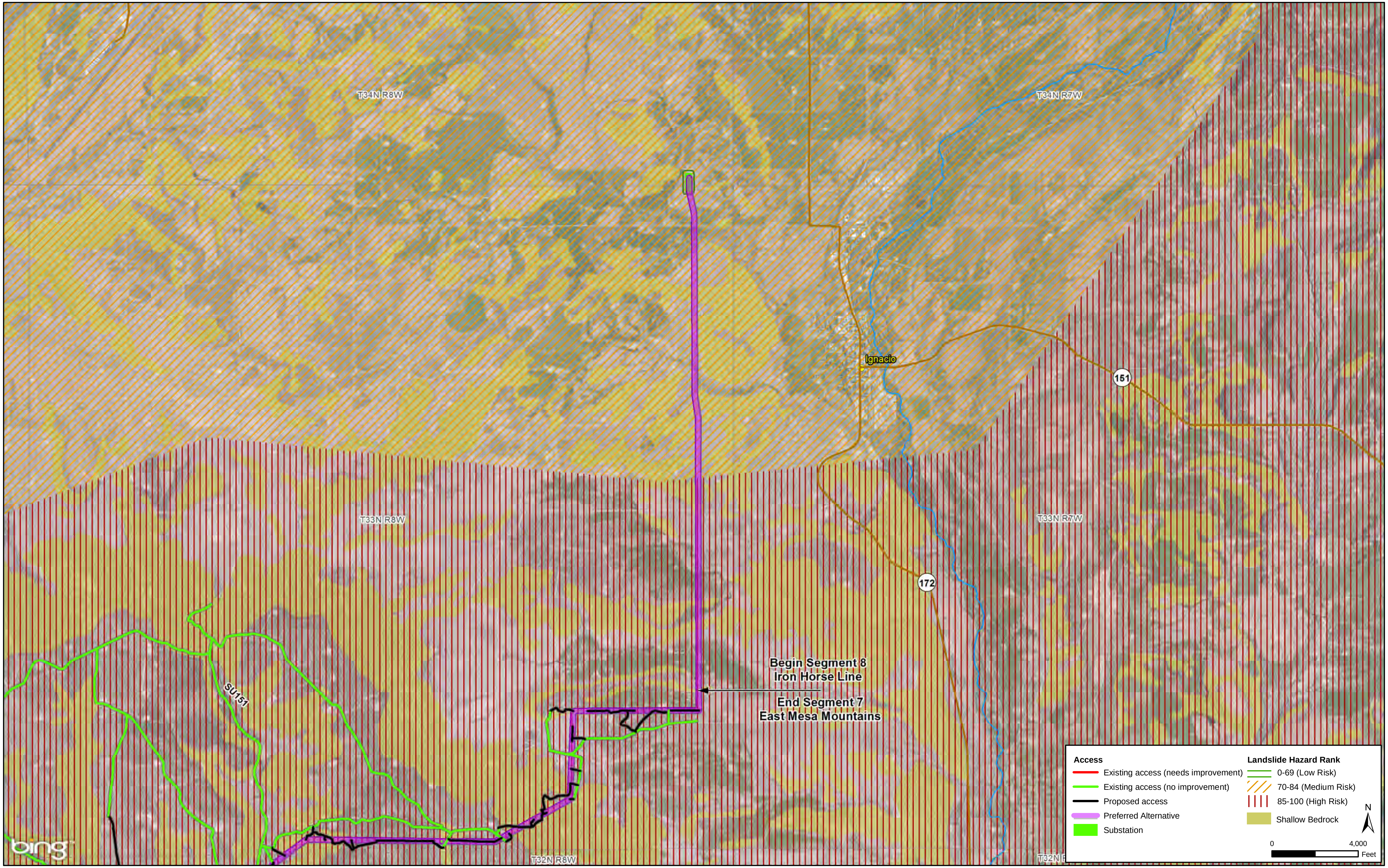
Source: FEMA 1996, USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-6 Preferred Alternative Segment 6 -- Geologic Hazards



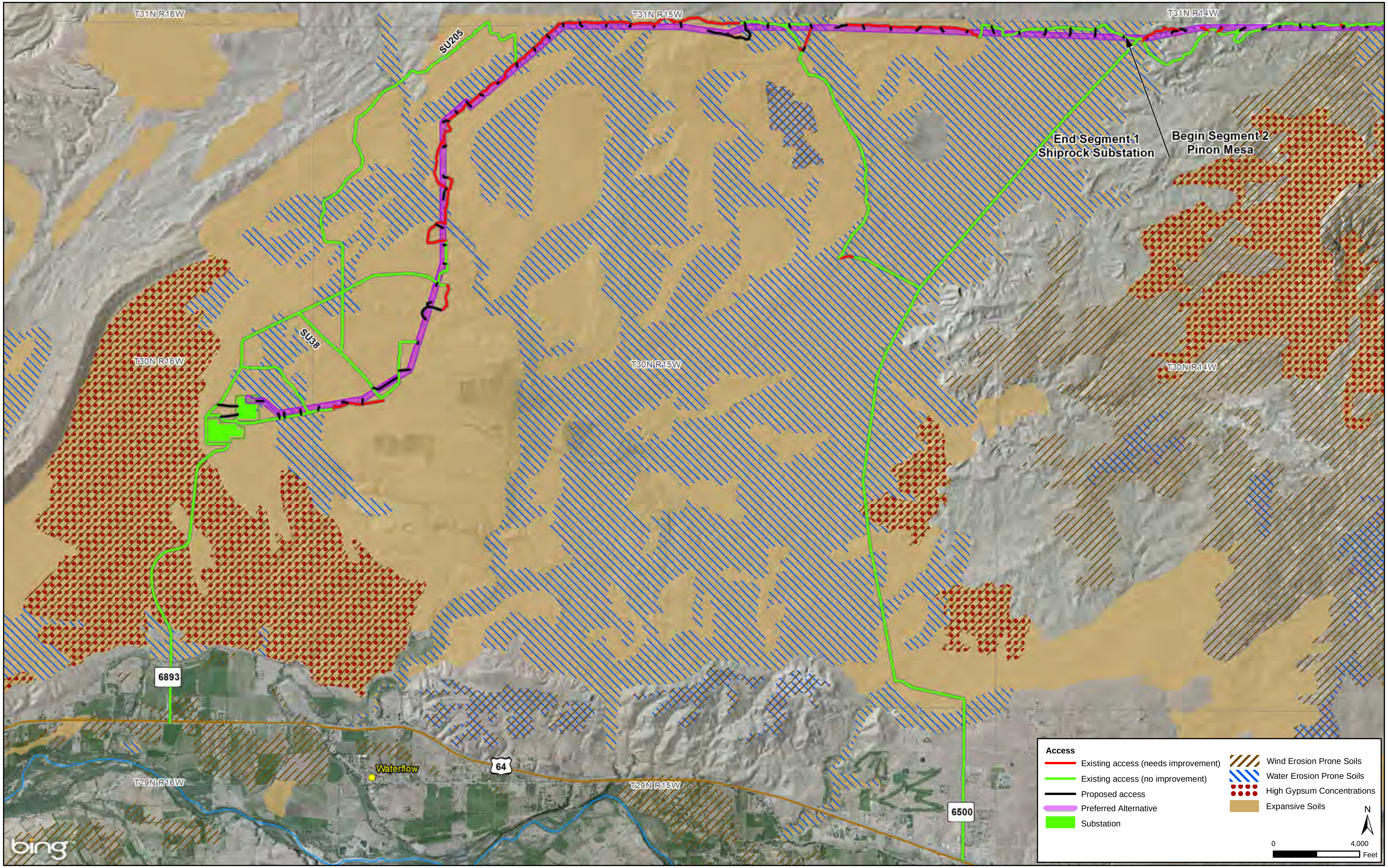
Source: FEMA 1996, USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-7 Preferred Alternative Segment 7 -- Geologic Hazards



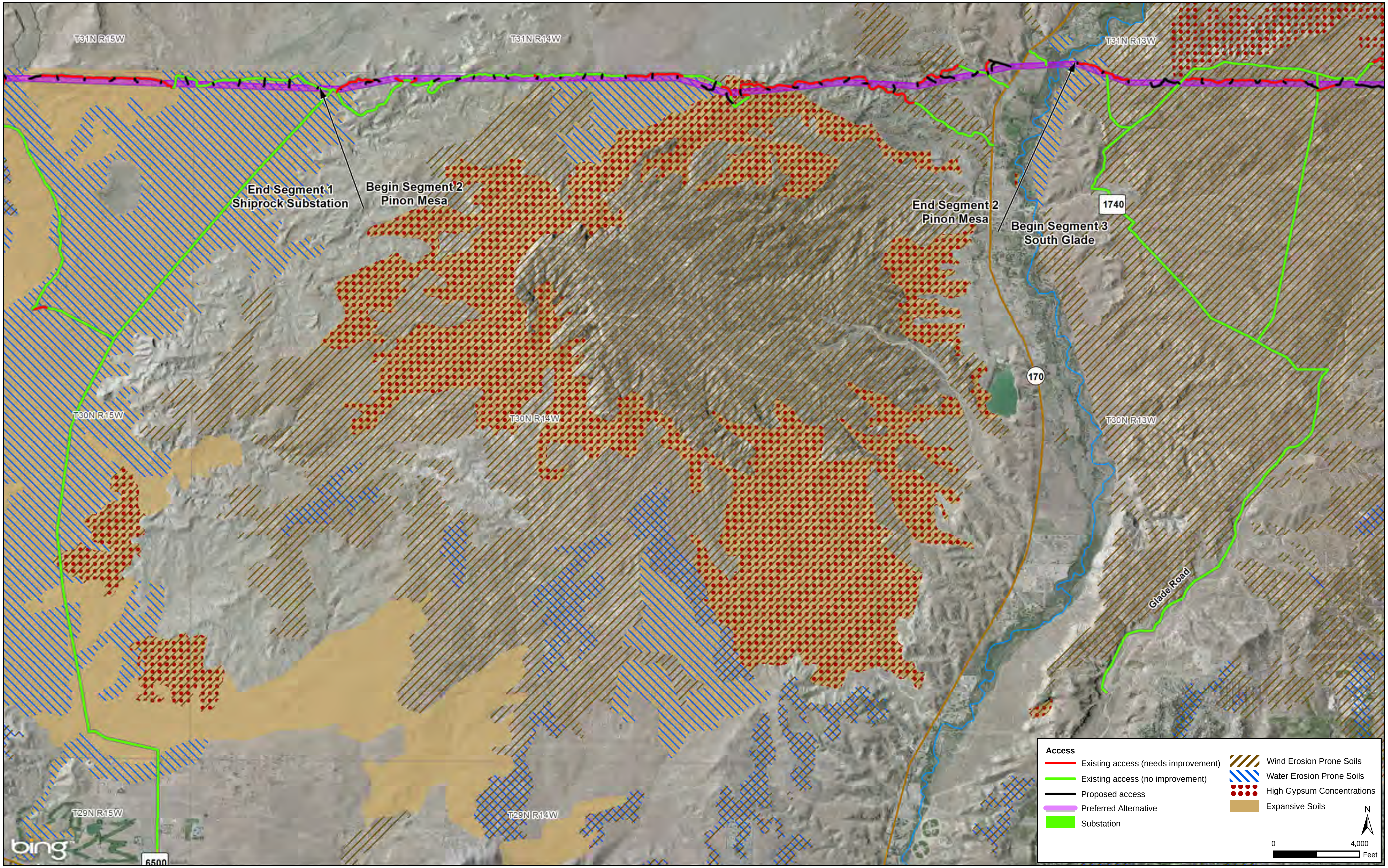
Source: FEMA 1996, USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-8 Preferred Alternative Segment 8 -- Geologic Hazards



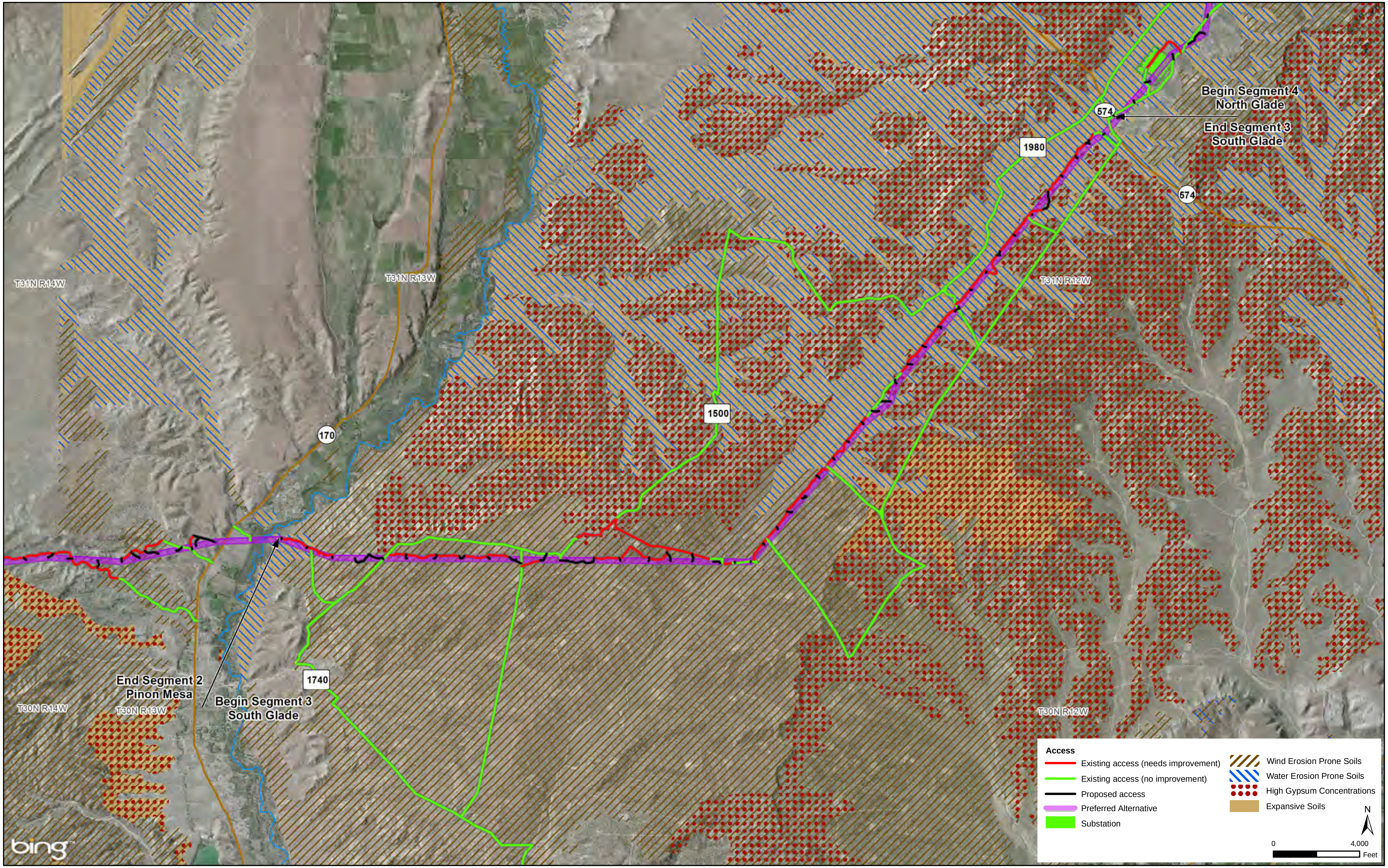
Source: USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-9 Preferred Alternative Segment 1 -- Potential Soil Hazards



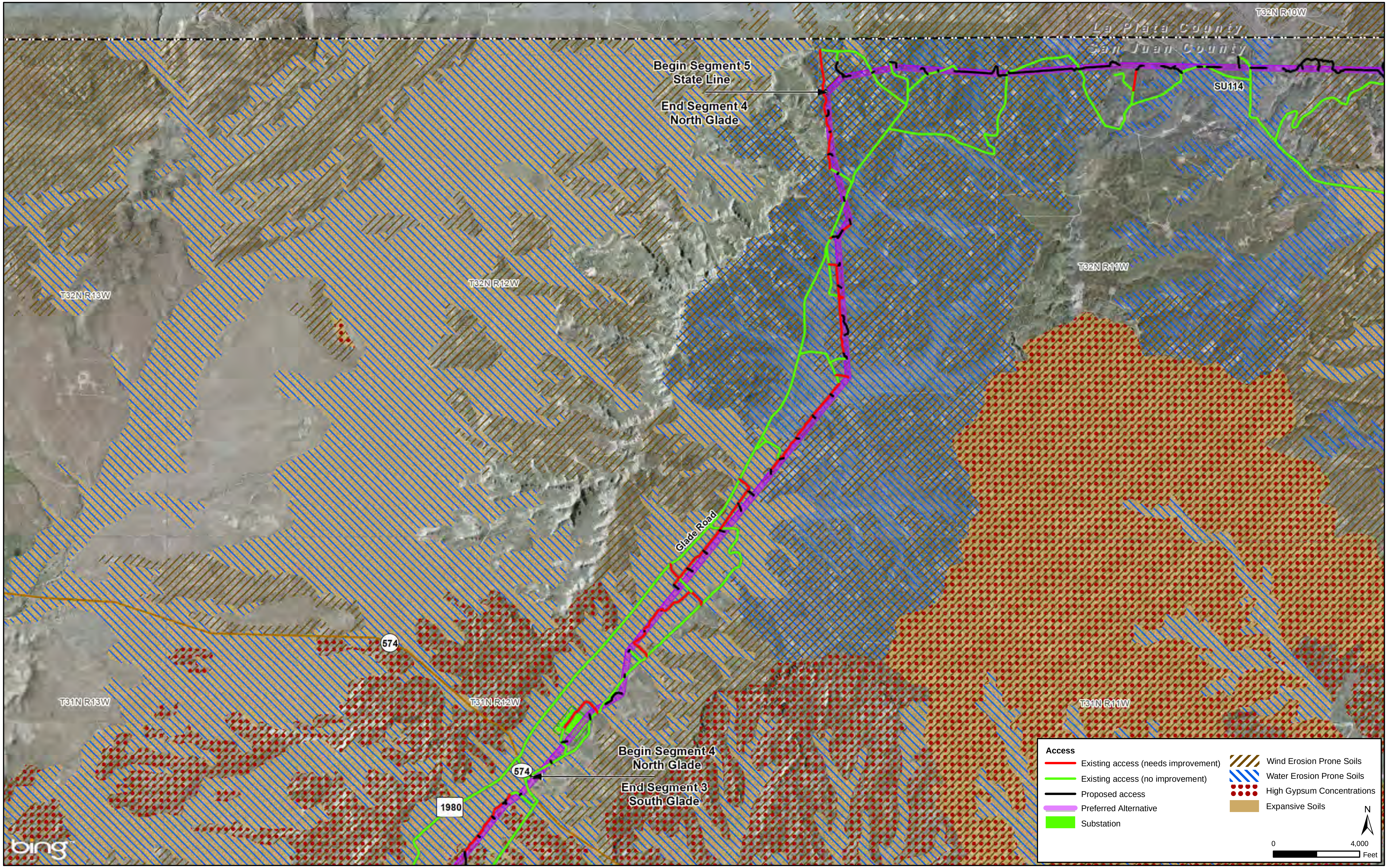
Source: USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-10 Preferred Alternative Segment 2 -- Potential Soil Hazards



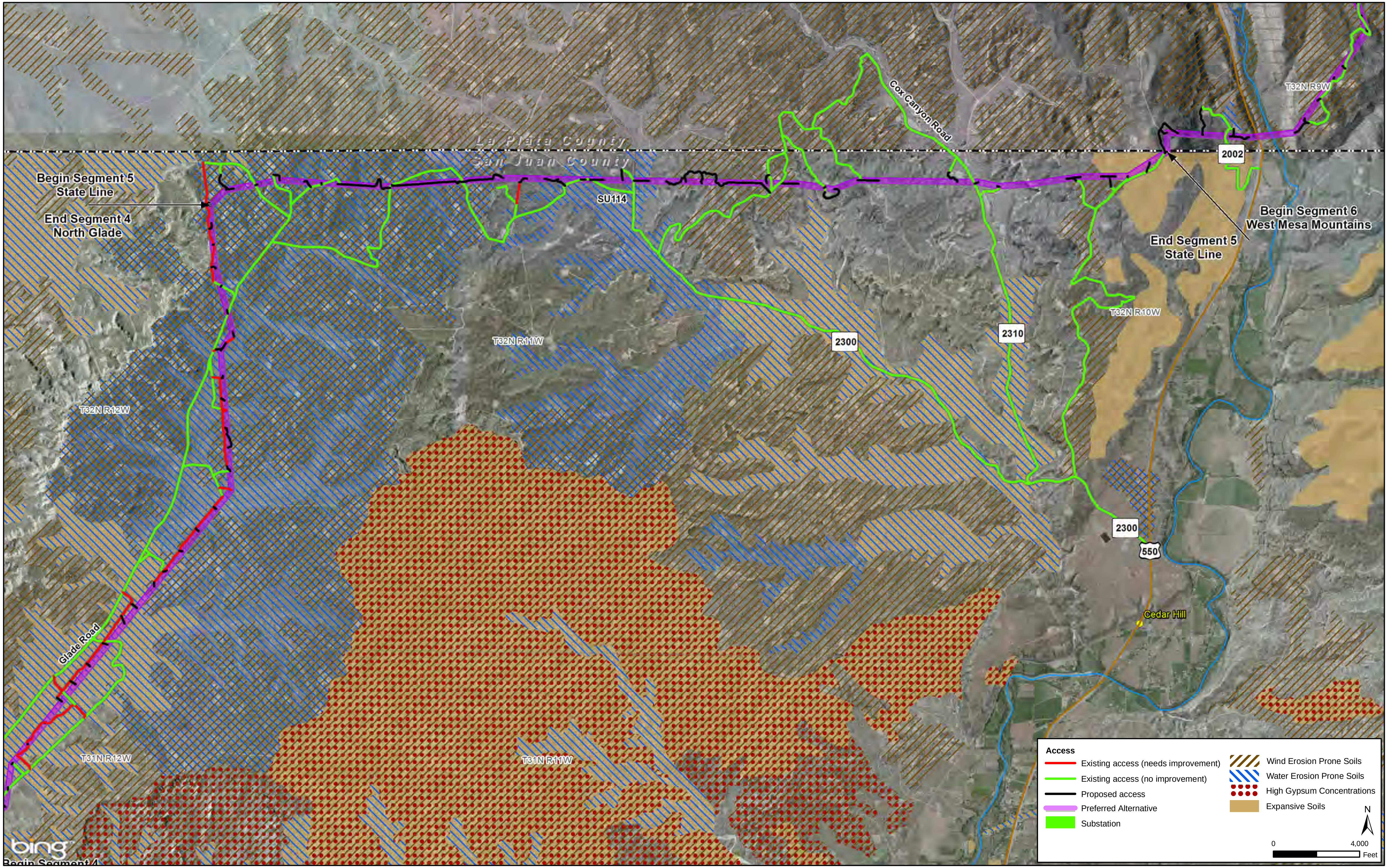
Source: USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-11 Preferred Alternative Segment 3 -- Potential Soil Hazards



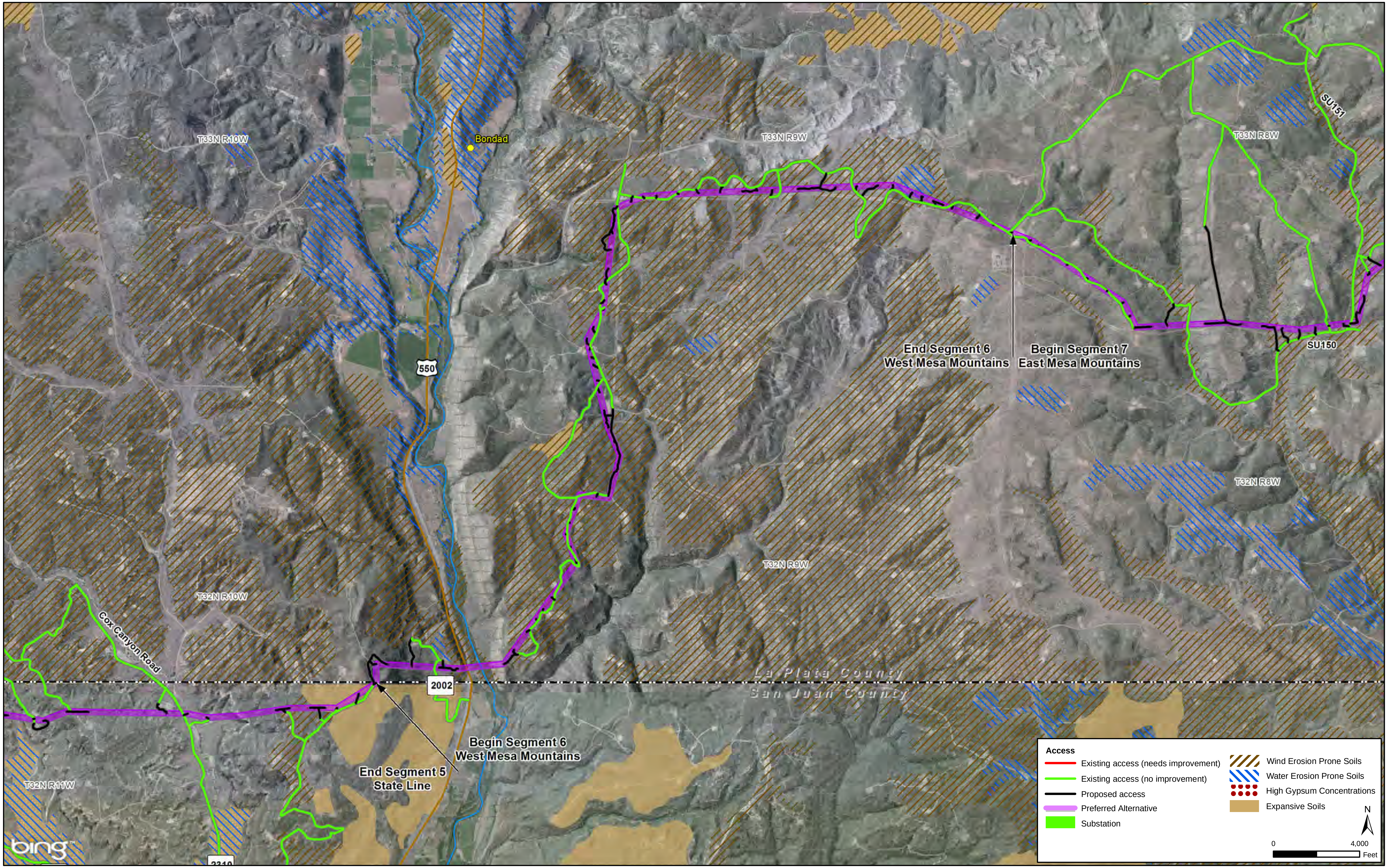
Source: USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-12 Preferred Alternative Segment 4 -- Potential Soil Hazards



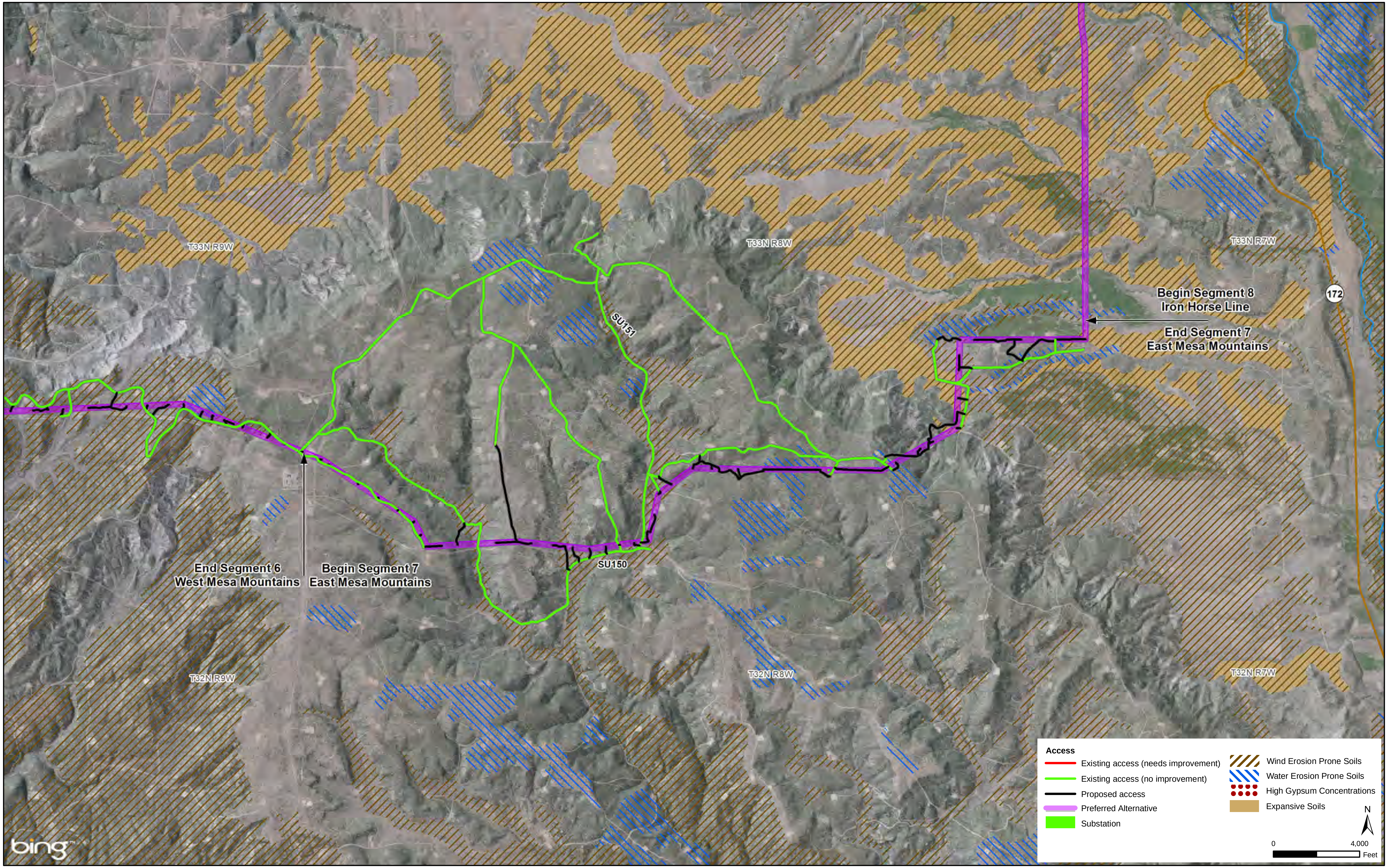
Source: USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-13 Preferred Alternative Segment 5 -- Potential Soil Hazards



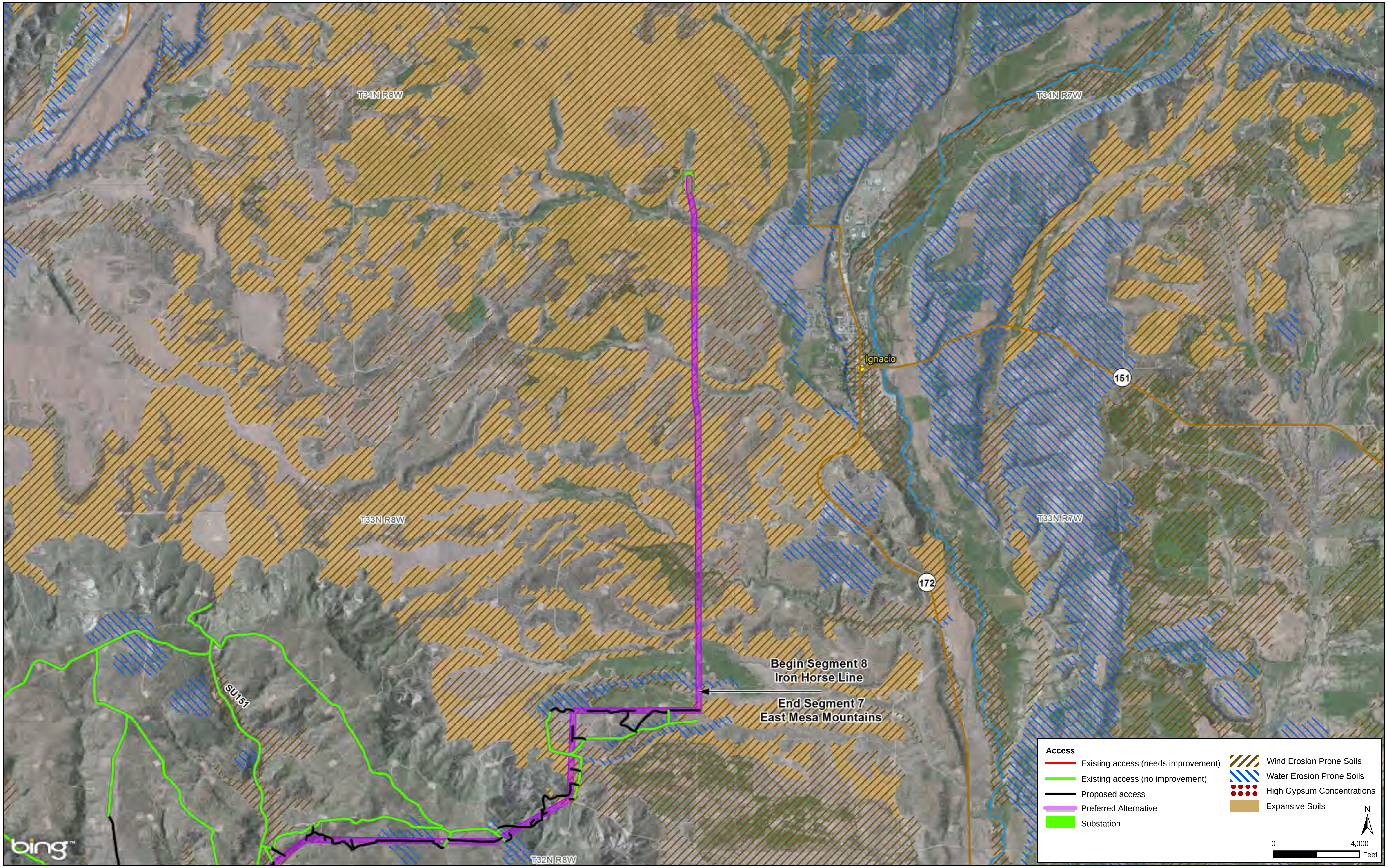
Source: USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-14 Preferred Alternative Segment 6 -- Potential Soil Hazards



Source: USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-15 Preferred Alternative Segment 7 -- Potential Soil Hazards



Source: USDA 2012, USDA 2009, USDA 2008, Tri-State 2013, Microsoft 2010

Exhibit G-16 Preferred Alternative Segment 8 -- Potential Soil Hazards

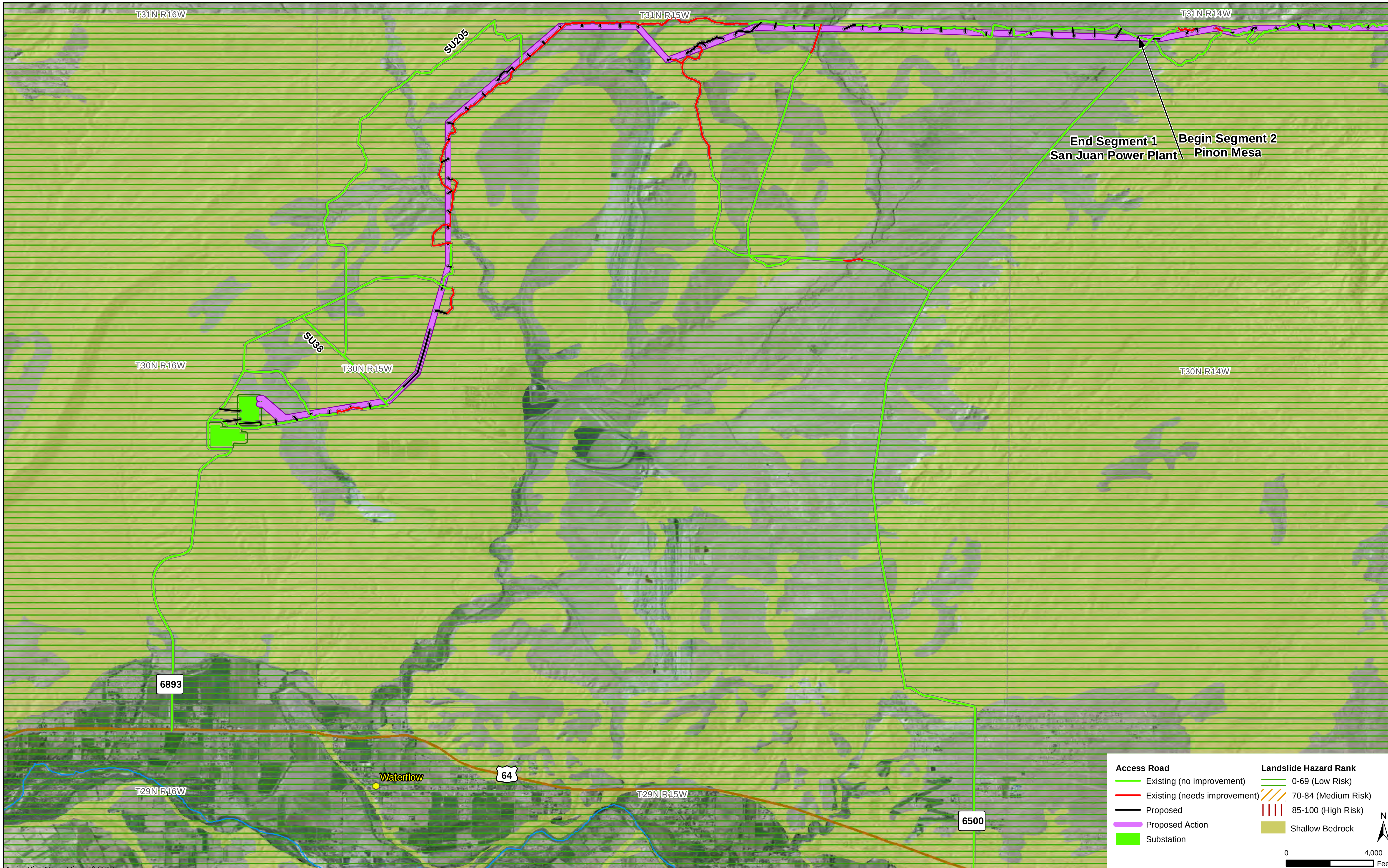


Exhibit G-17 Proposed Action Segment 1 -- Geologic Hazards

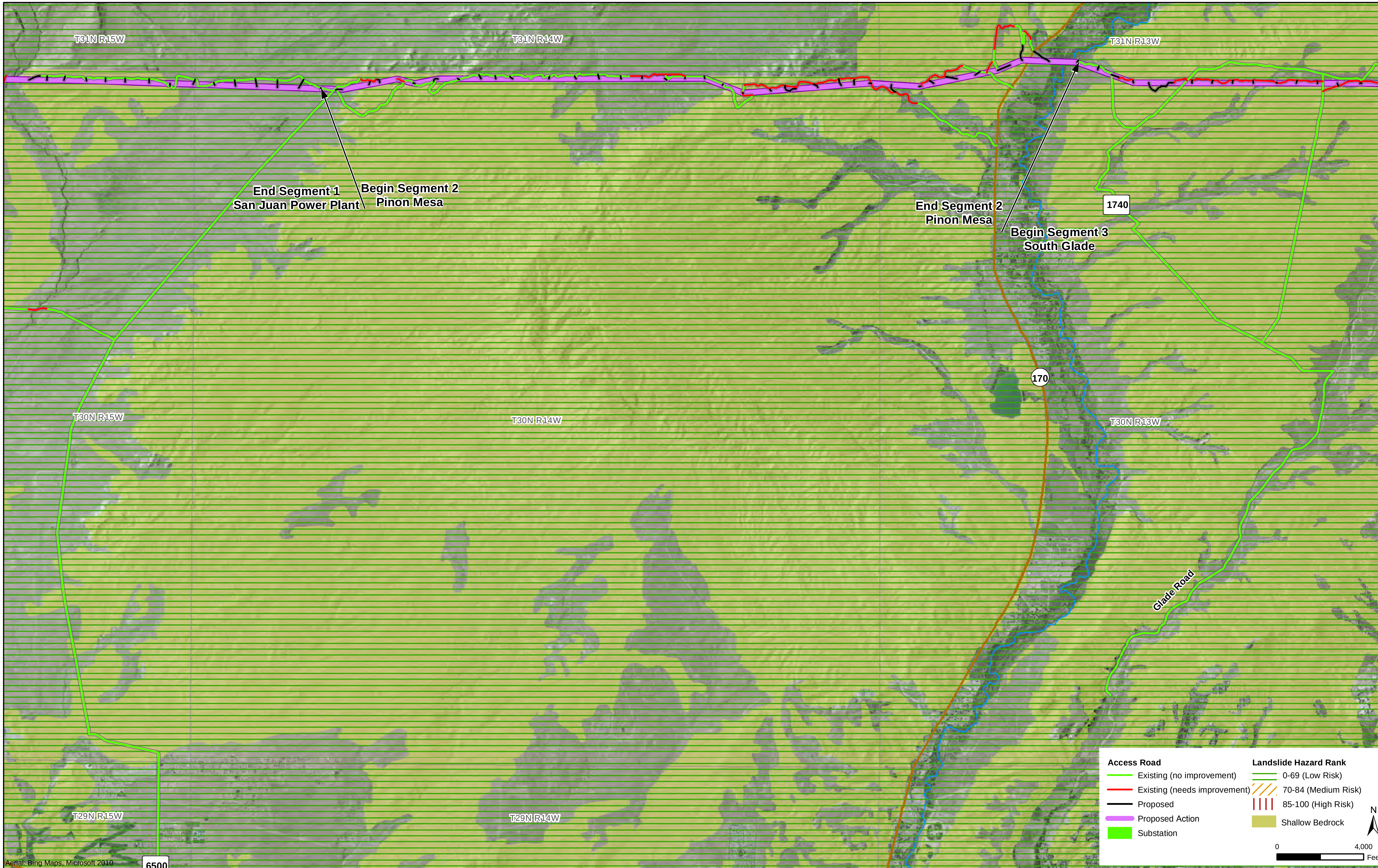


Exhibit G-18 Proposed Action Segment 2 -- Geologic Hazards

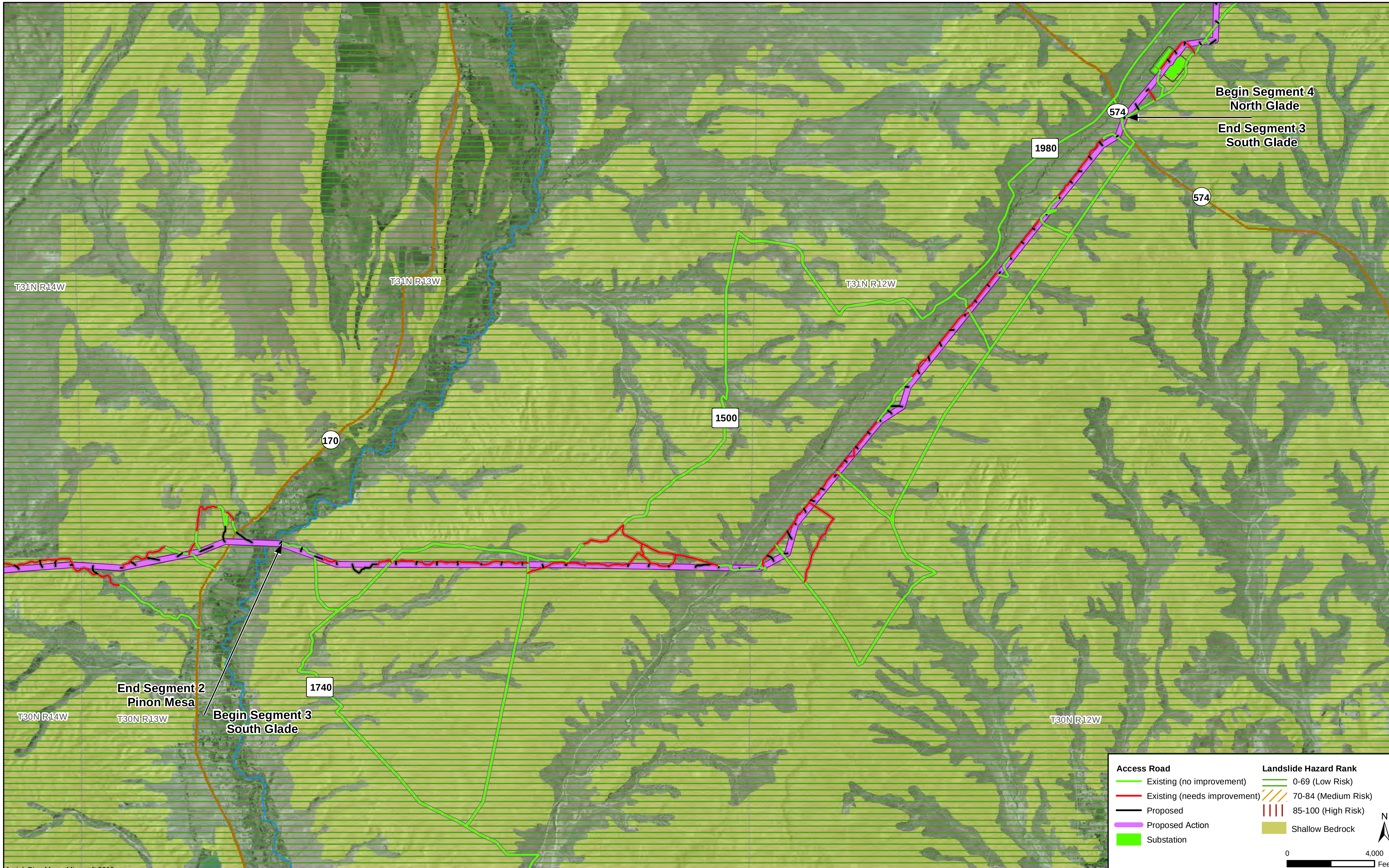


Exhibit G-19 Proposed Action Segment 3 -- Geologic Hazards

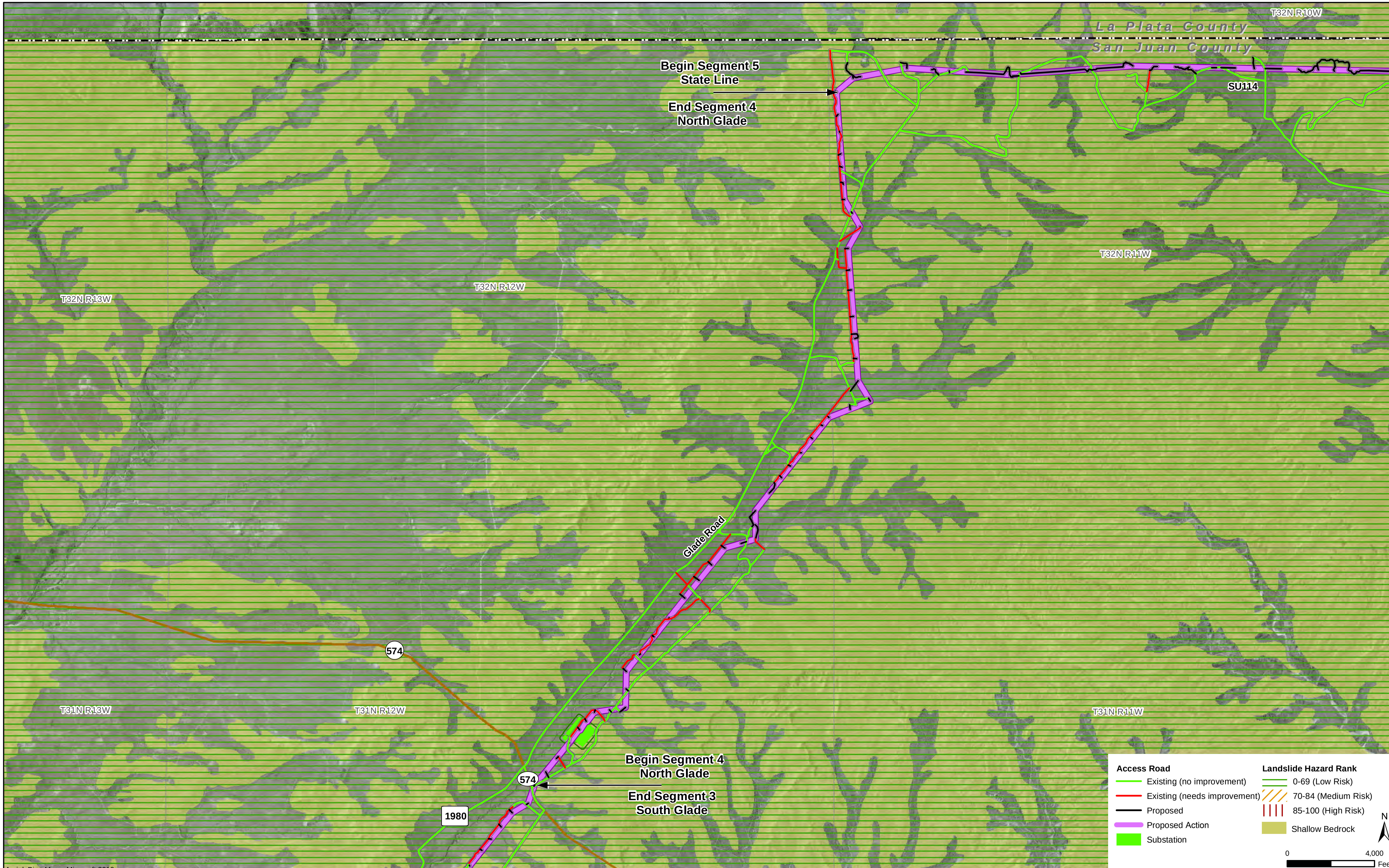


Exhibit G-20 Proposed Action Segment 4 -- Geologic Hazards

Exhibit G-21 Proposed Action Segment 5 -- Geologic Hazards

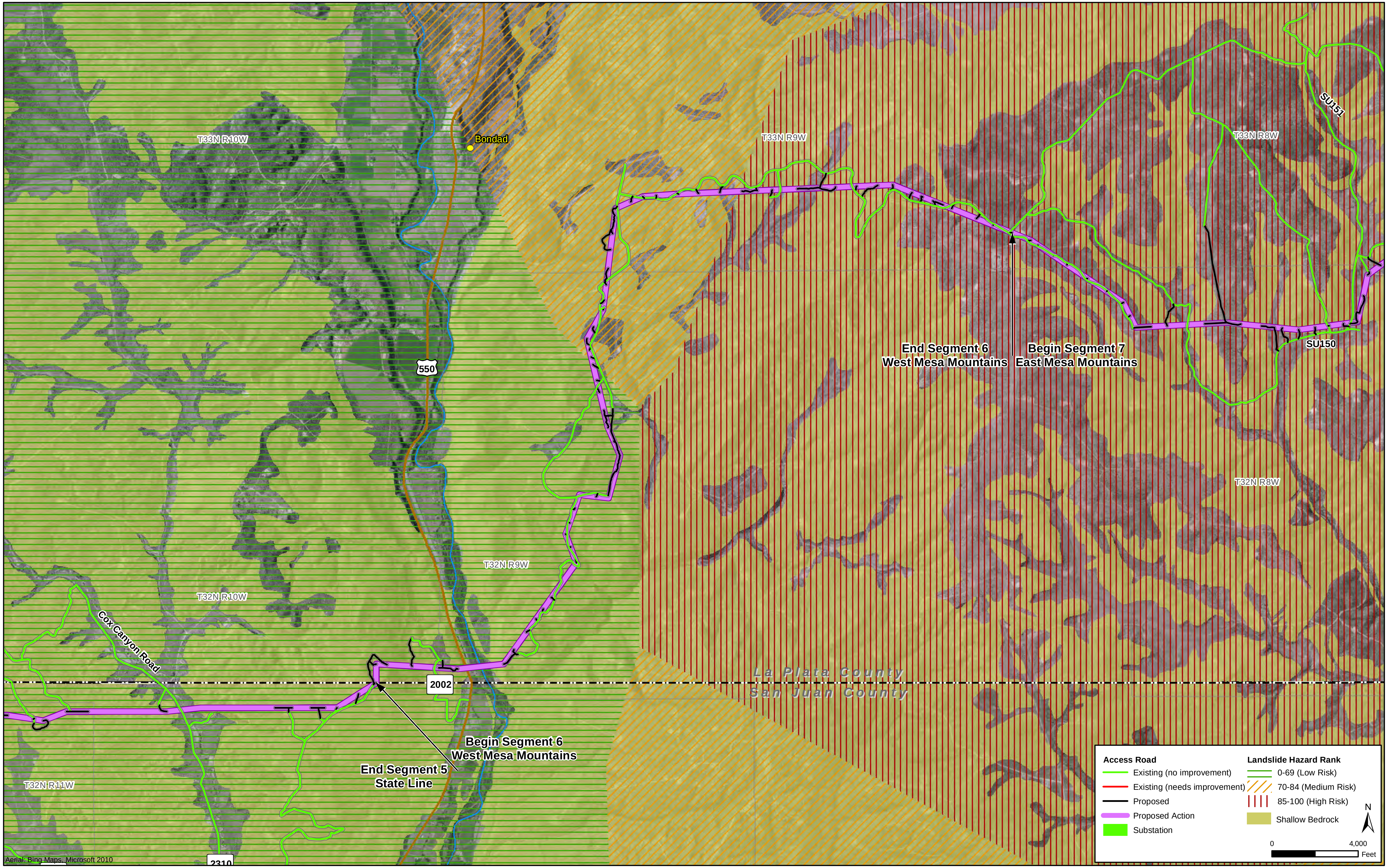


Exhibit G-22 Proposed Action Segment 6 -- Geologic Hazards

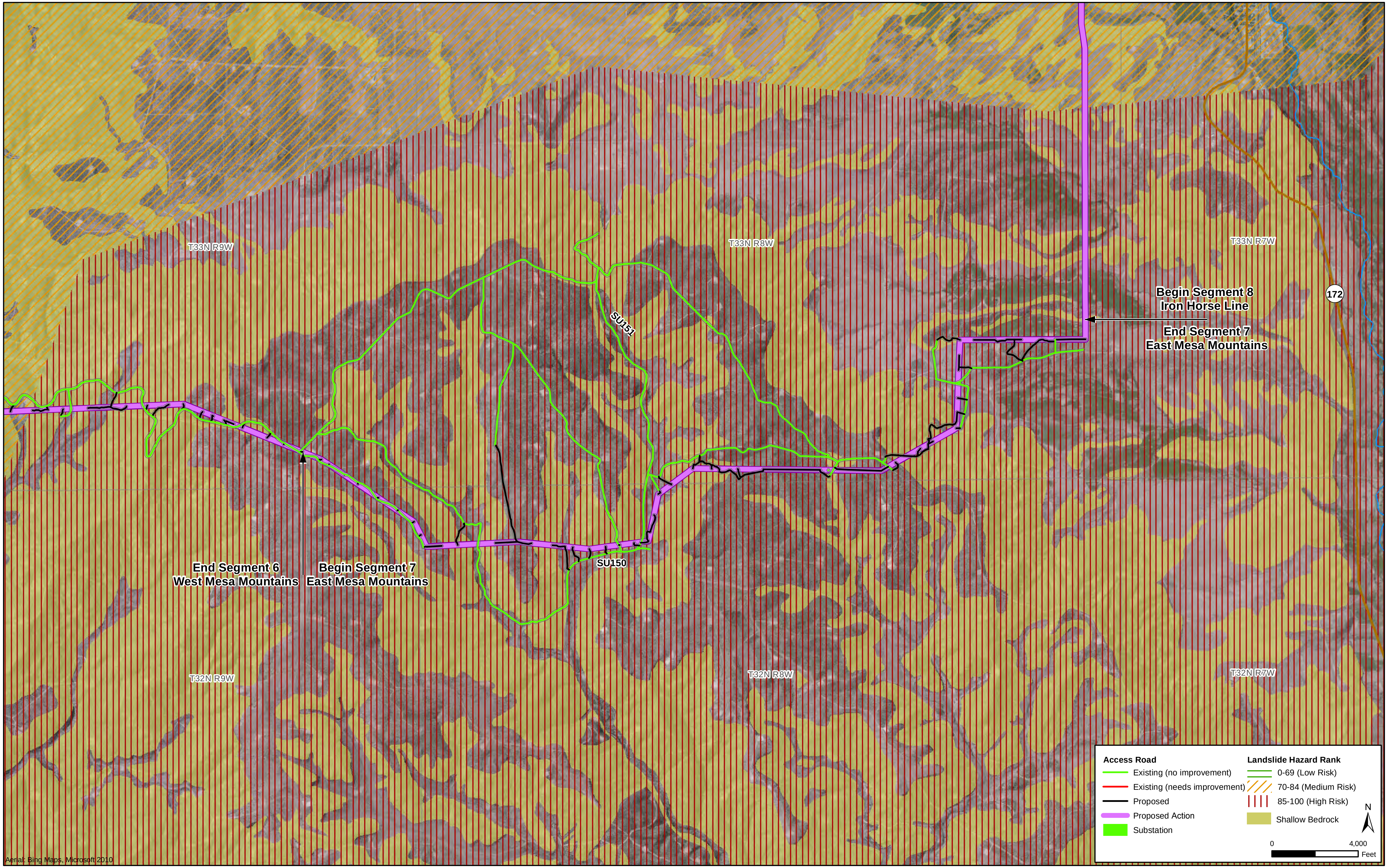


Exhibit G-23 Proposed Action Segment 7 -- Geologic Hazards

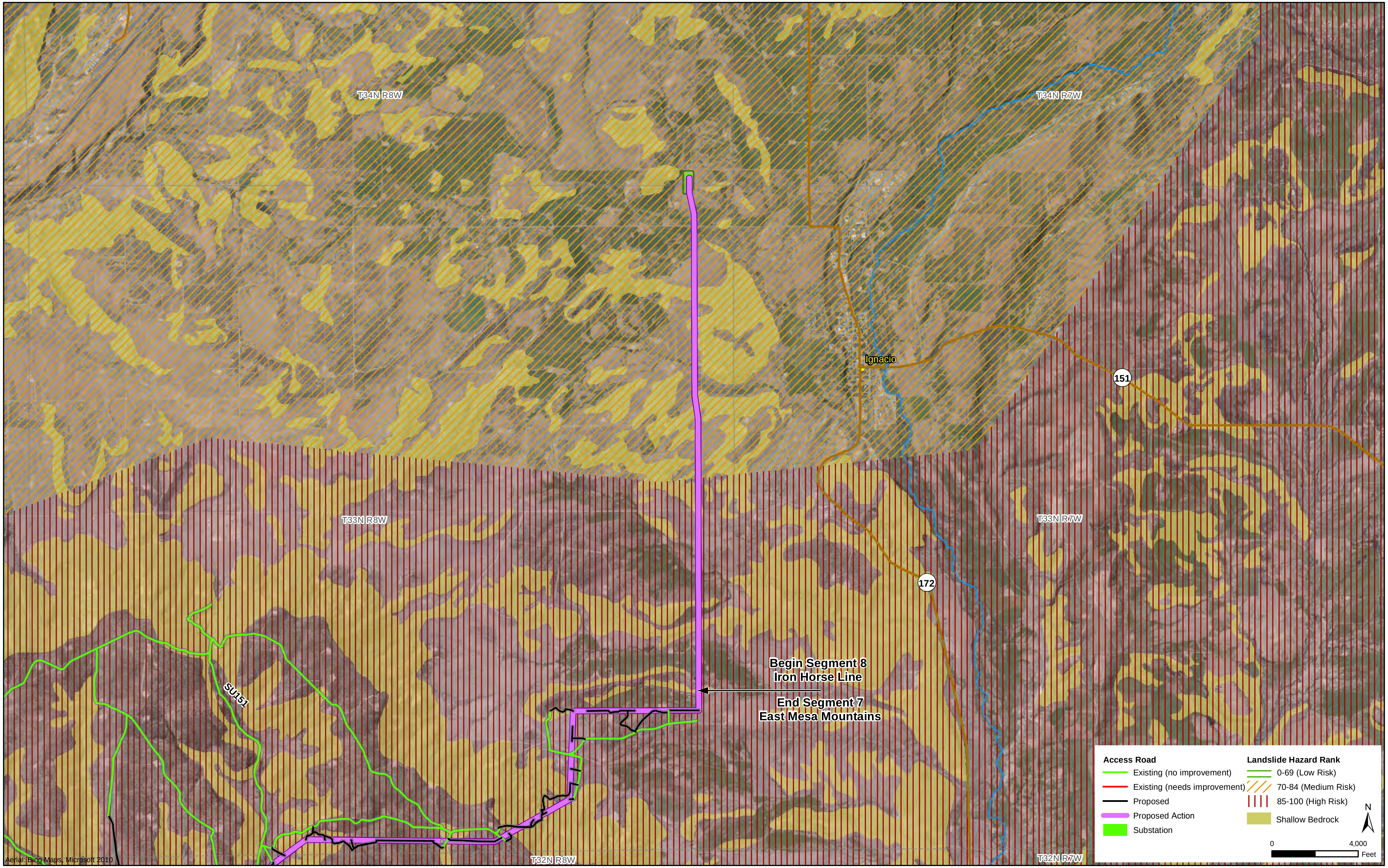


Exhibit G-24 Proposed Action Segment 8 -- Geologic Hazards

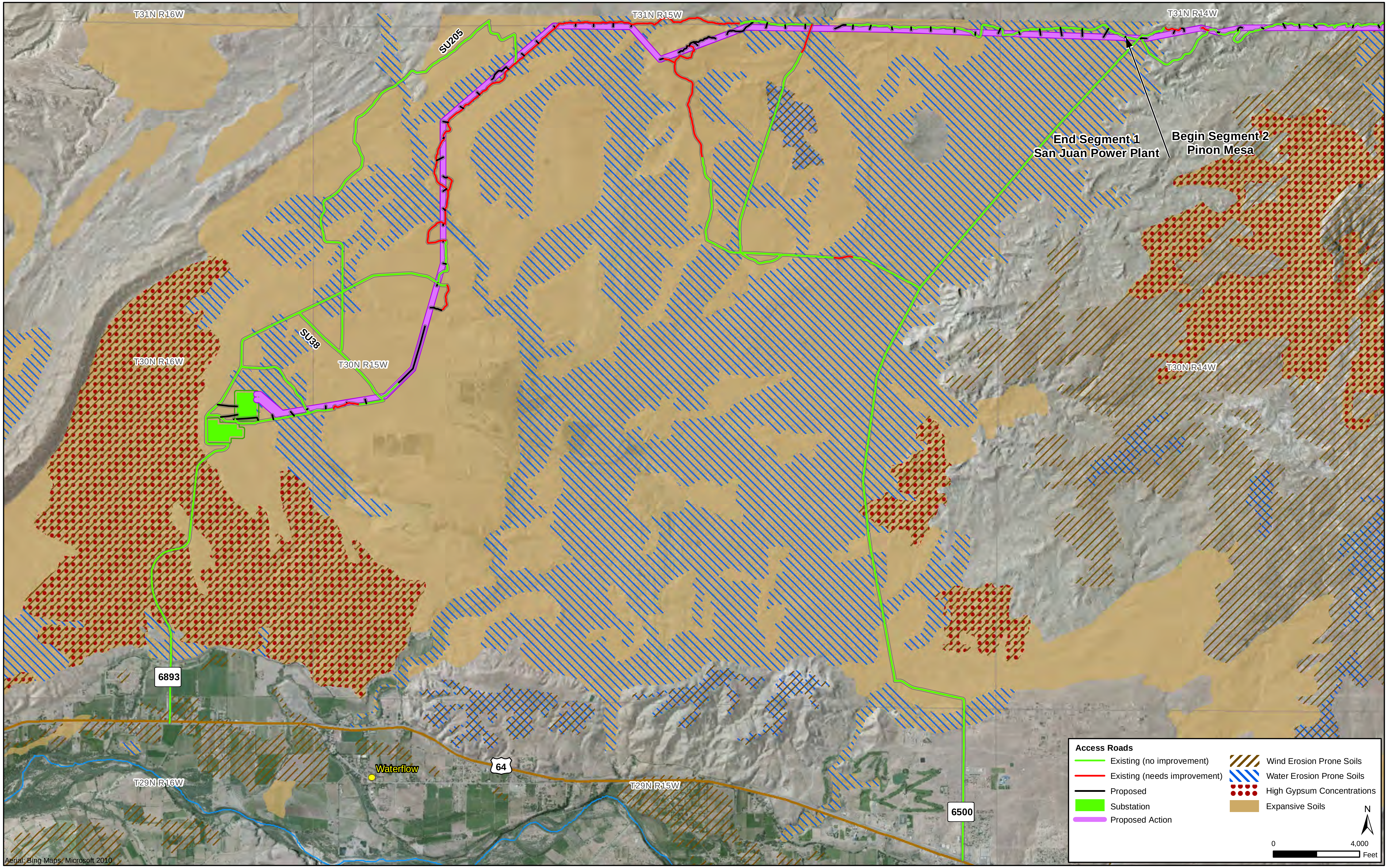


Exhibit G-25 Proposed Action Segment 1 -- Potential Soil Hazards

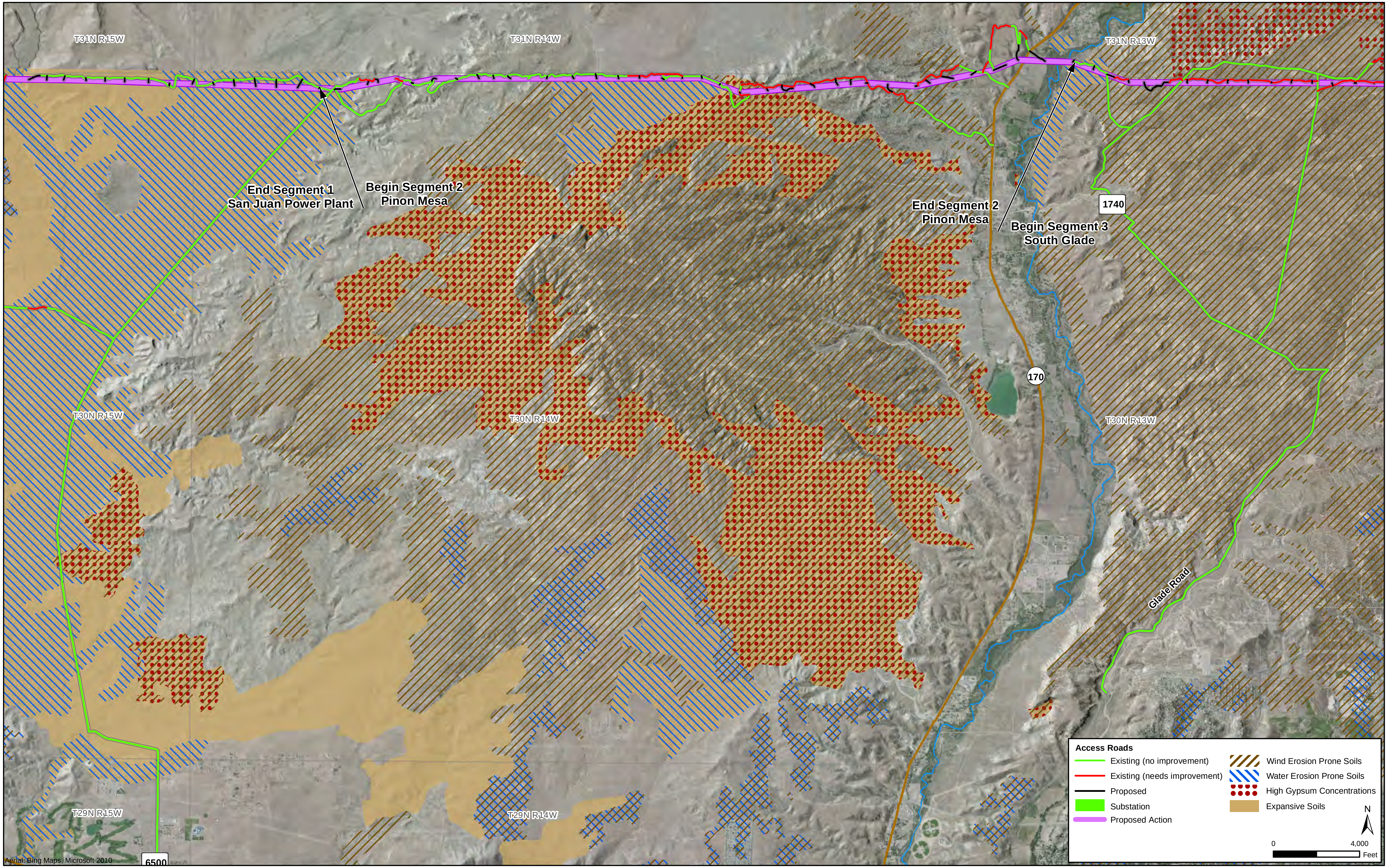


Exhibit G-26 Proposed Action Segment 2 -- Potential Soil Hazards

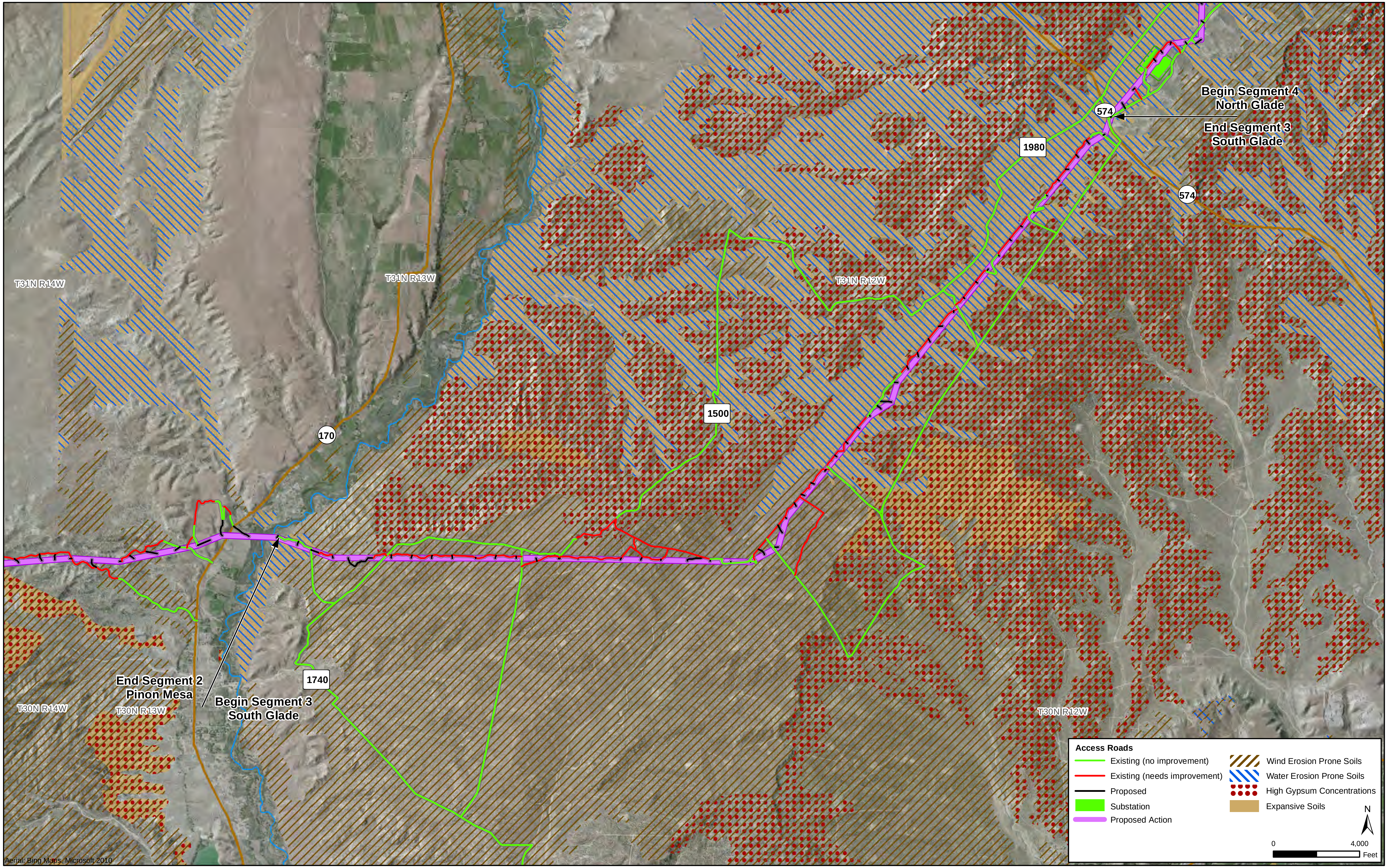


Exhibit G-27 Proposed Action Segment 3 -- Potential Soil Hazards

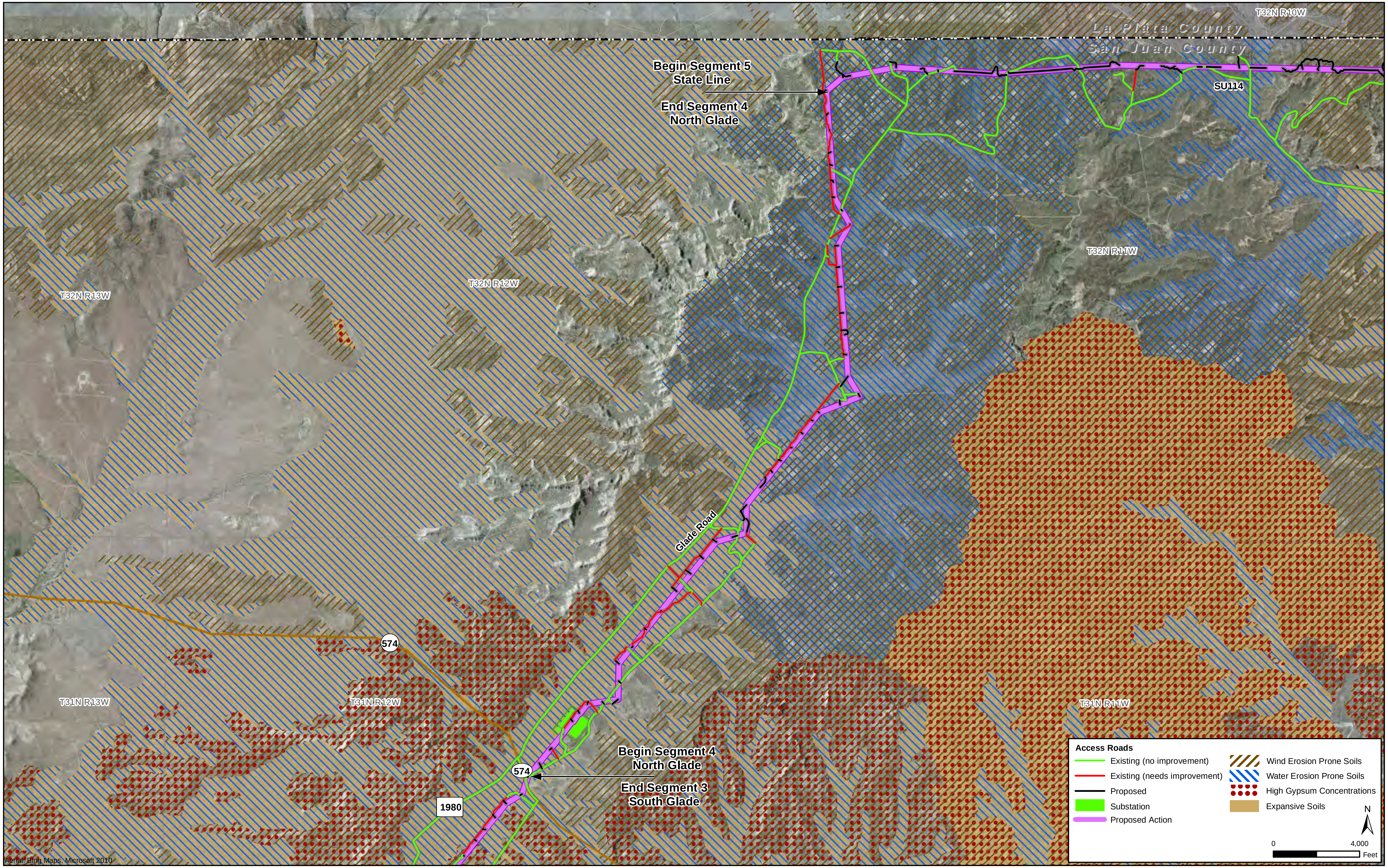


Exhibit G-28 Proposed Action Segment 4 -- Potential Soil Hazards

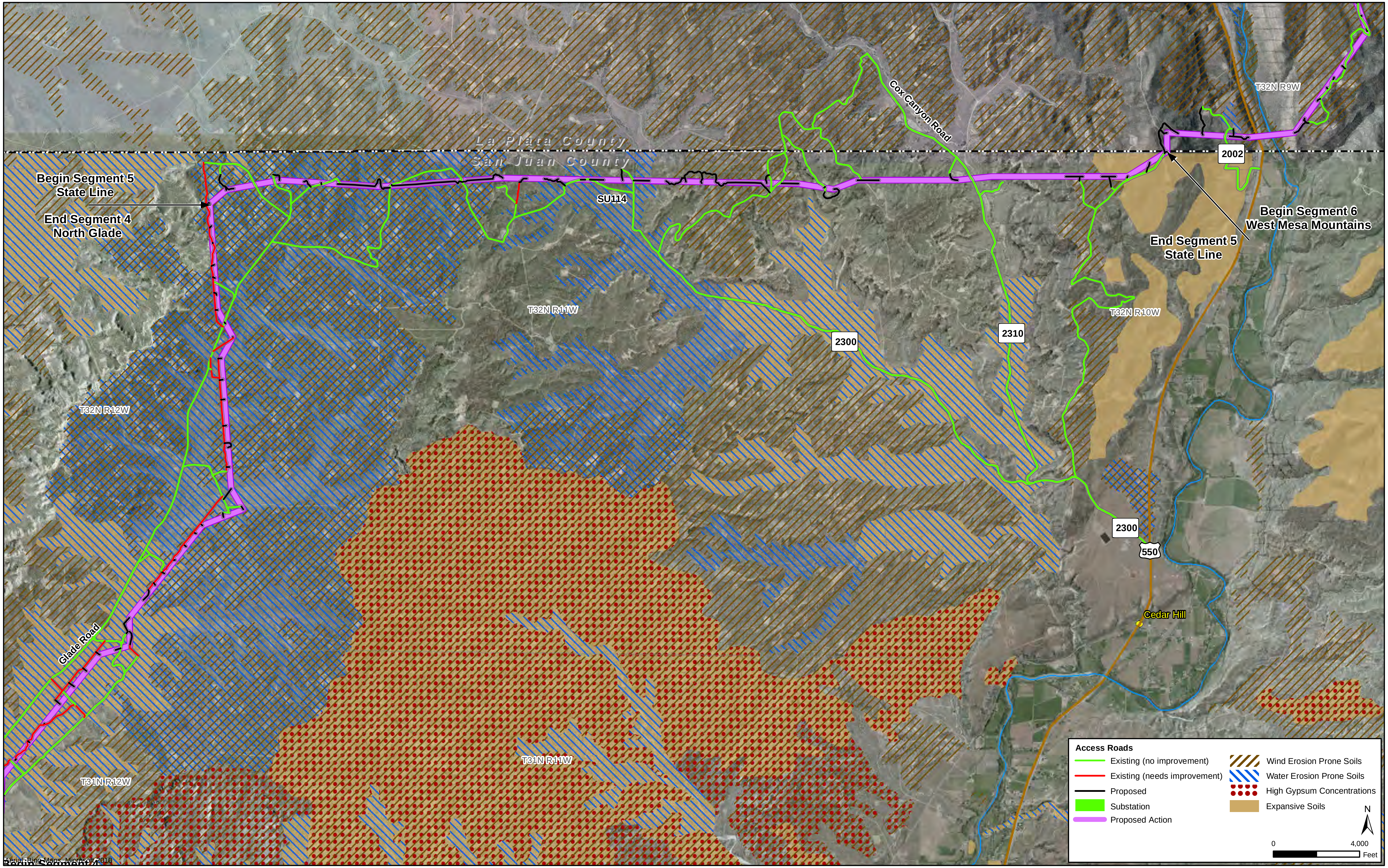


Exhibit G-29 Proposed Action Segment 5 -- Potential Soil Hazards

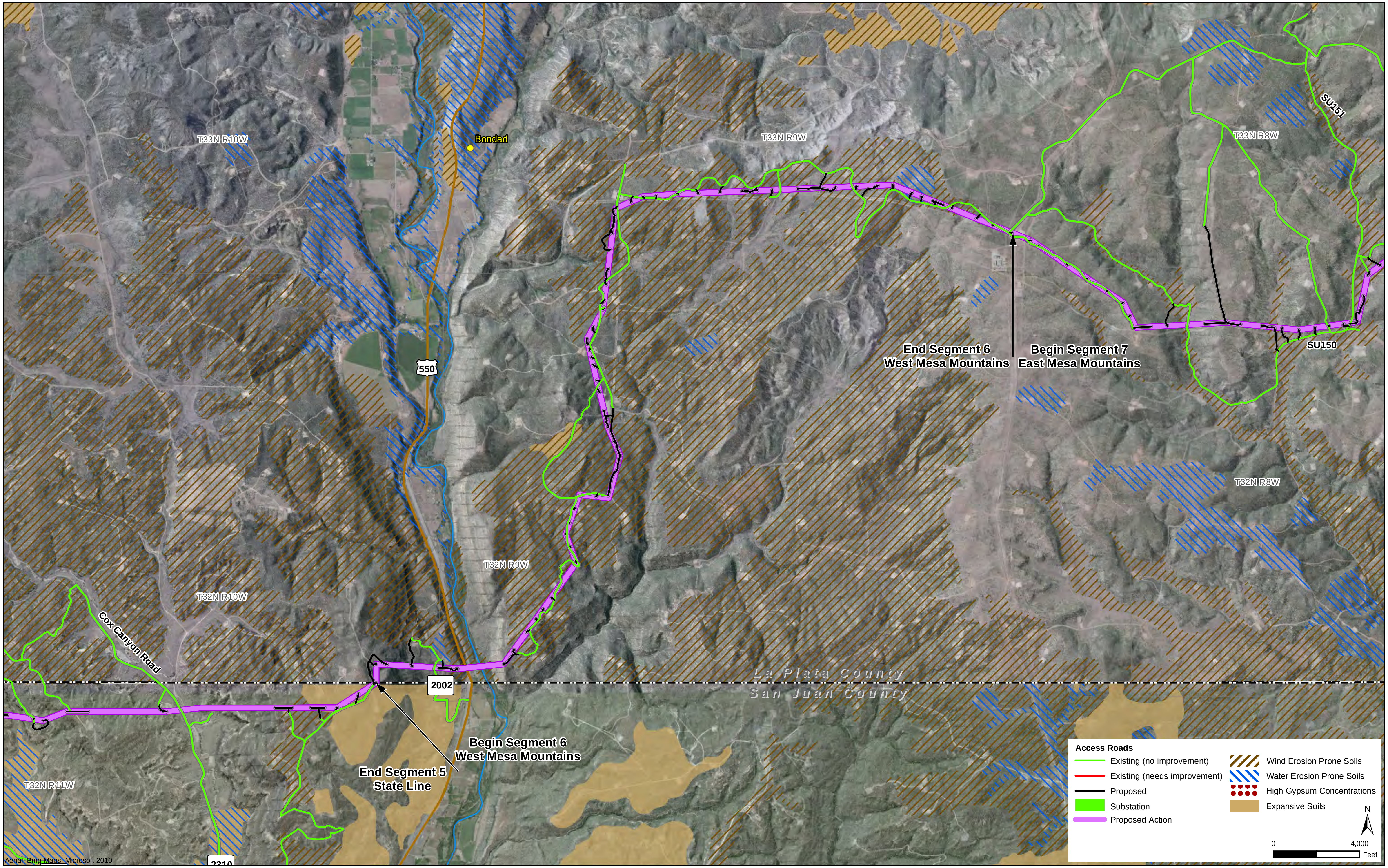


Exhibit G-30 Proposed Action Segment 6 -- Potential Soil Hazards

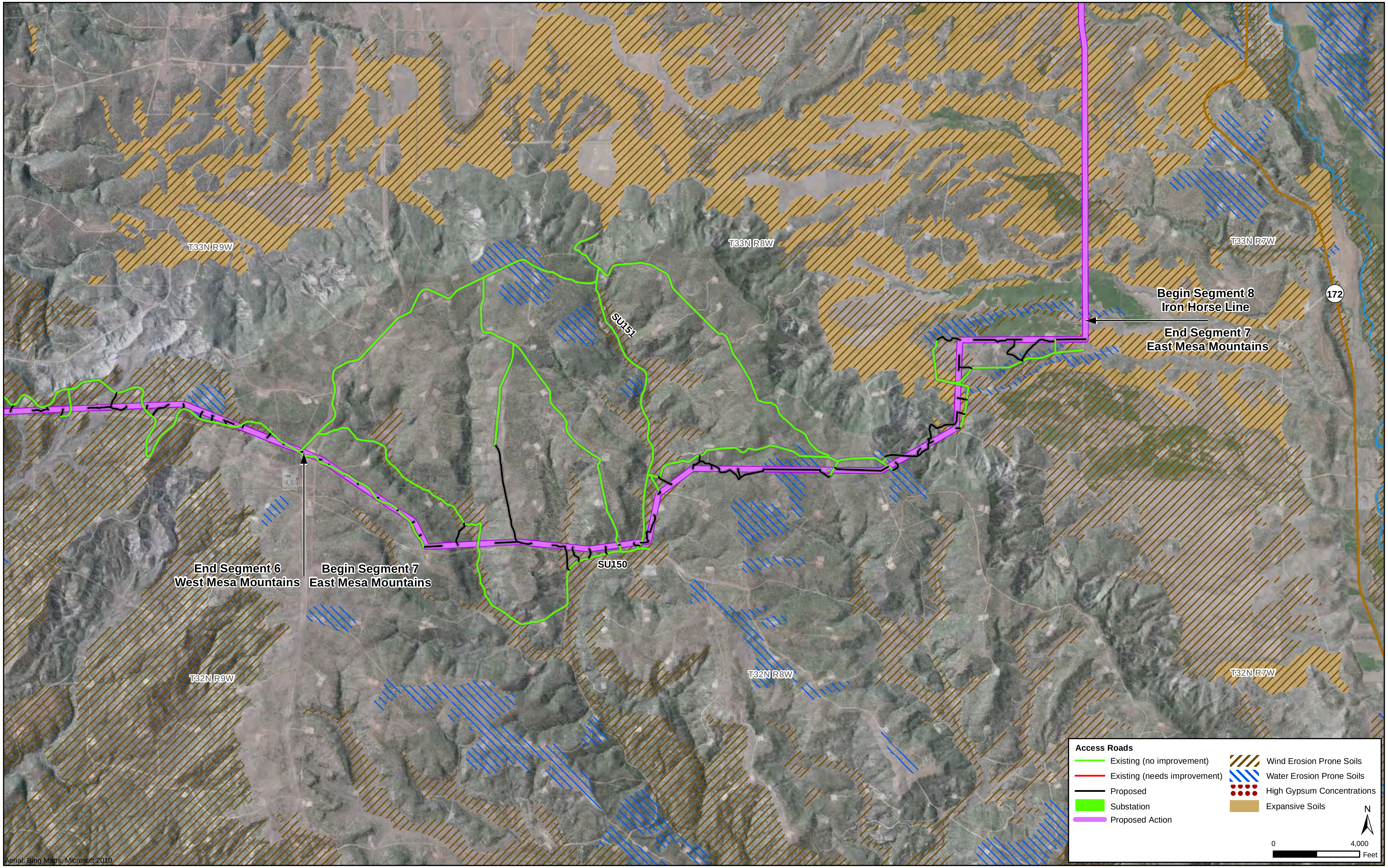


Exhibit G-31 Proposed Action Segment 7 -- Potential Soil Hazards

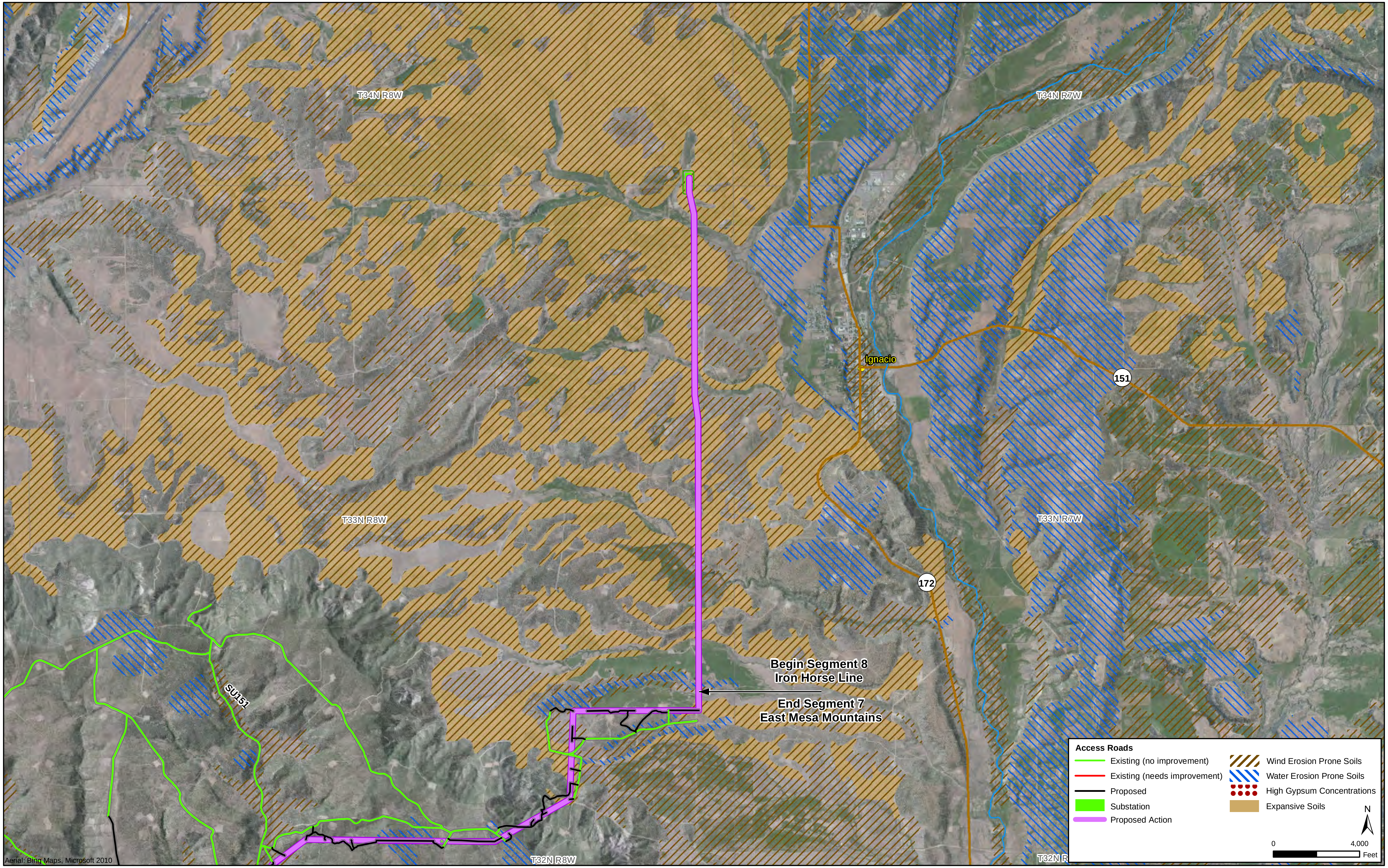


Exhibit G-32 Proposed Action Segment 8 -- Potential Soil Hazards